



# CITY OF ENCINITAS

## Leucadia Area Watershed Drainage Feasibility Study

**FINAL**



Prepared by



*Consulting*

*In association with*

**Michael Baker**  
INTERNATIONAL

DECEMBER 2022

**City of Encinitas**  
**Leucadia Area Watershed Drainage**  
**Feasibility Study**  
San Diego County, California

***FINAL REPORT***

December 2022

*Prepared for:*



**City of Encinitas**  
505 South Vulcan Avenue  
Encinitas, CA 92024

*Prepared by:*



27042 Towne Centre Drive, Suite 110  
Foothill Ranch, CA 92610  
*Contact:* Thomas J. Ryan, RCE C61701

JN 40.034.000

This page intentionally left blank.

## Table of Contents

|       |   |    |
|-------|---|----|
| 1     | Introduction .....  | 1  |
| 1.1   | Project Overview .....  | 1  |
| 1.2   | Goals and Objectives .....                                    | 2  |
| 2     | Project Approach and Design Criteria.....                     | 5  |
| 2.1   | Background.....   | 5  |
| 2.2   | Study Area Watersheds .....                                   | 7  |
| 2.2.1 | Leucadia Focused Subareas.....                                | 7  |
| 2.2.2 | Old Encinitas Focused Area .....                              | 11 |
| 2.3   | Design Criteria.....  | 11 |
| 2.3.1 | Design Constraints .....                                      | 11 |
| 2.4   | Data Research .....   | 14 |
| 2.5   | Technical Software Description .....                          | 15 |
| 3     | Hydrology.....  | 16 |
| 3.1   | Methodology.....  | 16 |
| 3.2   | Precipitation.....  | 16 |
| 3.2.1 | Land Use Designations.....                                    | 17 |
| 3.2.2 | Soil Type .....   | 17 |
| 3.3   | Loss Rate Calculations .....                                  | 17 |
| 4     | Flood Routing Analyses .....                                  | 21 |
| 4.1   | Methodology.....  | 21 |
| 4.1.1 | Topography .....  | 21 |
| 4.1.2 | Vertical Datum .....  | 21 |
| 4.1.3 | 1-D Model Geometry .....                                      | 21 |
| 4.1.4 | Manning’s “n” Value.....                                      | 21 |
| 4.1.5 | Grid Size.....  | 22 |
| 4.1.6 | Computational Time Step.....                                  | 22 |
| 4.2   | Existing Condition.....                                       | 22 |
| 4.2.1 | Hydraulic Boundary Conditions.....                            | 22 |
| 4.2.2 | Model Correlation .....                                       | 23 |
| 4.2.3 | Existing Condition Model Results .....                        | 29 |
| 4.3   | Proposed Condition .....                                      | 30 |
| 4.4   | Cost Estimates .....  | 31 |
| 5     | Water Quality .....   | 33 |
| 5.1   | Green Infrastructure.....                                     | 33 |
| 5.2   | Structural BMPs .....   | 35 |
| 5.3   | Dry Weather Flow Diversion.....                               | 35 |
| 6     | Drainage Area Results.....                                    | 37 |
| 6.1   | L101 Area Alternative (Future Improvement).....               | 37 |
| 6.2   | Vulcan Subarea (Future Improvement) .....                     | 40 |
| 6.3   | South Leucadia Subarea (Future Improvement).....              | 49 |
| 6.4   | East Leucadia Subarea (Future Improvement) .....              | 57 |
| 6.5   | Union Street/Vulcan Avenue Special Flood Area Discussion..... | 57 |
| 6.6   | Old Encinitas Subarea (Future Improvement).....               | 59 |
| 6.7   | Project Prioritization and Phasing .....                      | 59 |

|   |                   |    |
|---|-------------------|----|
| 7 | Conclusions ..... | 62 |
|---|-------------------|----|

## Figures

|  |    |
|--|----|
| Figure 1-1. Vicinity Map ( <i>Use actual PDF here</i> ) .....                            | 3  |
| Figure 1-2. Project Location Map ( <i>Use Actual PDF</i> ) .....                         | 4  |
| Figure 2-1. Leucadia Subareas ( <i>Use actual PDF here</i> ) .....                       | 8  |
| Figure 2-2. Old Encinitas Subarea ( <i>Use actual PDF here</i> ) .....                   | 13 |
| Figure 3-1. Distributed Rainfall/Land Use Map (Replace w/ PDF) .....                     | 18 |
| Figure 3-2. Hydrologic Soils Map (Replace w/ PDF).....                                   | 19 |
| Figure 4-1. Union St. 2014 validation Storm (Replace w/ PDF).....                        | 24 |
| Figure 4-2. Parking lot 2014 Validation Storm (Replace with PDF).....                    | 25 |
| Figure 4-3. Leucadia Park 2019 Validation Storm (Replace with PDF) .....                 | 26 |
| Figure 4-4: December 12, 2014 Storm Results for Leucadia West of I-5 (Use PDF) .....     | 27 |
| Figure 4-5: January 21, 2010 Storm Results for Leucadia West of I-5 (Use PDF) .....      | 28 |
| Figure 6-1. Ponto Basins Configuration .....   | 39 |
| Figure 6-2. L101 Ultimate Outlet Configuration .....                                     | 40 |
| Figure 6-3. Schematic of Vulcan System and Laterals(Use PDF).....                        | 43 |
| Figure 6-4. V-1 Lateral Alignment (Use PDF).....   | 44 |
| Figure 6-5. V-2 Lateral Alignments (Use PDF).....  | 45 |
| Figure 6-6. V-3 Lateral (Use PDF) .....  | 46 |
| Figure 6-7. Schematic of South System and Laterals .....                                 | 51 |
| Figure 6-8. S-1 Lateral Alignment.....   | 52 |
| Figure 6-9. S-2 Lateral Alignment.....   | 53 |
| Figure 6-10. Union St./Vulcan Ave. Flooded Area Ultimate Storm Drain Configuration ..... | 58 |
| Figure 6-11. Flood Control System Priority Map (Use PDF).....                            | 61 |

## Exhibits

Exhibits 1-12. Existing Condition Results - Maximum Depth Maps (XPStorm)  
Exhibits 13-17. Proposed Condition Results - Maximum Depth Maps (XPStorm)  
Exhibits 18. Green Infrastructure Sample Potential Sites Map

## Technical Appendix

- A. Concept Plans
- B. Existing Condition Calculations
- C. Project Condition Calculations

# 1 INTRODUCTION

## 1.1 Project Overview

The City of Encinitas (City) has experienced a history of flooding, especially within the Leucadia area. Much of the recurring flooded areas are located in relatively flat terrain with minimal or restricted drainage infrastructure. This area has been subject to several studies and evaluations over the last few decades, resulting in potential regional solutions that were never constructed due to budget and regulatory constraints. With the technological improvements over the last few years in stormwater modeling, the City wanted to take a “new look” at the flooding issues with the focus of identifying more feasible solutions. This study will also evaluate the effectiveness of using “green” infrastructure to provide flood mitigation. Consequently, the City requested services specializing in hydrologic and hydraulic modeling to re-evaluate the Leucadia and Old Encinitas areas and prepare a detailed and watershed-scale master plan using a more advanced and “robust” modeling software.



*Vulcan Avenue/Union Street, December 12, 2014*

This flooding issues plaguing the Leucadia area have been well documented over that past several decades. Multiple reports and studies have been prepared to understand and identify potential flood control solutions. Many of these proposed flood control solutions were rejected due to environmental restrictions, cost to construct, and community backlash.

### Receiving Water Bodies

As a coastal community surrounded by beaches and Lagoons, water quality impacts should be considered in any flood control solution. For the Leucadia and Old Encinitas watersheds, the main receiving water bodies are the Batiquitos Lagoon, Moonlight Beach (Cottonwood Creek), and directly to the ocean. Currently, all the runoff from these two watersheds ends up in one of these three locations. Any non-storage (retention) related flood control solutions will change the timing of the peak discharge, but the volume of discharge would remain nearly unchanged, since the watershed is completely developed.

### Coastal Bluffs

The bluffs that line most of the coast along Leucadia are highly unstable. As recently as August 2<sup>nd</sup>, 2019, a portion of oceanfront bluff collapsed at Grandview Beach, resulting in three deaths. A recent study, “*Encinitas and Leucadia Watersheds Preliminary Stormwater Infiltration Hazard Zones*”, prepared by Dudek (November 15, 2019), provided a preliminary evaluation associating the stability of the bluffs with respect to soil saturation. The findings suggested that induced percolation could destabilize the bluffs further. The study recommendation was to “*avoid any increase in surface water infiltration through the use of bioretention best management practices*” in the area bounded by Vulcan Avenue (to the east) and the ocean (west), pending further investigations. This recommendation minimizes the potential to propose regional or local infiltration practices beyond the existing conditions.

Previous drainage studies of the Leucadia area used traditional stormwater modeling techniques. The most recent studies were prepared using a combination HEC-1 (or HEC-HMS) for hydrology and HEC-RAS or WSPGW (1-dimensional models) for hydraulics. Although these modes are common, they are based on simplistic methods, lacking the capability to accurately analyze complex urban environments.

For drainage areas that are extremely flat with restricted outlet conditions, these models will not provide a as realistic of a picture for the current flooding issues or potential feasible solutions.

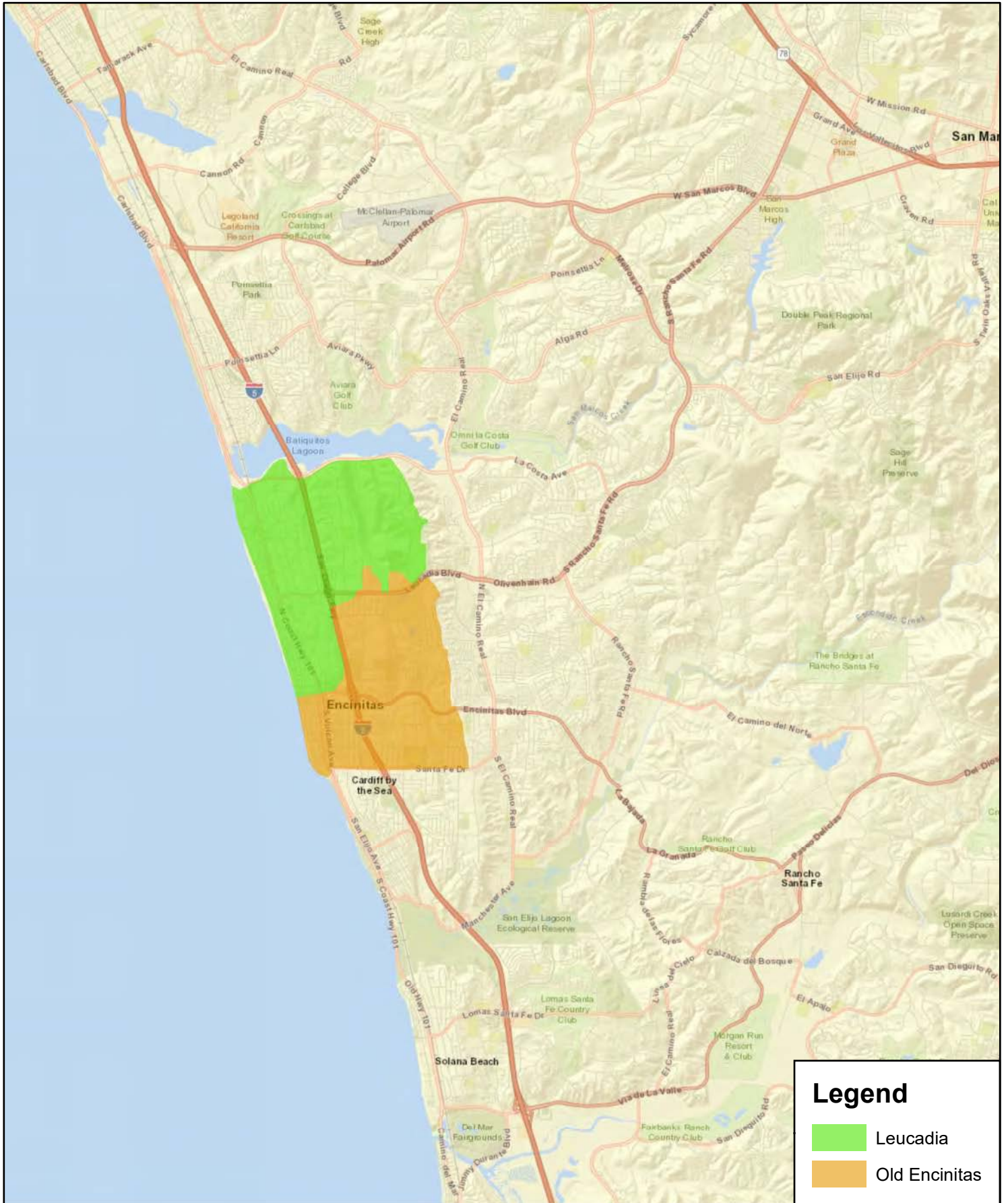
## **1.2 Goals and Objectives**

The purpose of this report is to evaluate and identify feasible drainage solutions while minimizing adverse impacts to water quality of the receiving water bodies. This study presents a detailed engineering analysis for the proposed flood control improvements within the Leucadia and Old Encinitas areas. A detailed analysis of the existing drainage conditions set the baseline for developing multiple potential stormwater alternative improvements. This study provides the framework for future final calculations and design of recommended projects.

The primary procedure of this study includes the following:

- Research, collect, and review previous studies and storm drain improvement plans completed in the watershed.
- Understand and compile community concerns and input.
- Establish the design criteria, methodology, and requirements to be used for the hydrologic and hydraulic studies and for the determination of the appropriate level of flood protection.
- Identify and potential project restrictions and various agency regulations.
- Prepare design hydrology to be used for the flood routing analysis.
- Complete a flood routing analysis to determine flooding patterns and maximum flood depths in the study area.
- Correlate (or validate) the results of the flood routing model to known flooding from the actual storm events.
- Evaluate existing system deficiencies and develop conceptual drainage solutions for identified flood hazard areas.
- Identify applicable “green infrastructure” opportunities with respect to flood control.
- Prepare preliminary construction cost estimates for the recommended drainage improvements.
- Prepare a detailed report to document the studies and support the recommended improvements.

Although this study was prepared using advanced stormwater modeling methods, efforts were made to utilize some of the San Diego County Hydrology guidelines with respect to design storm rainfall and loss rate calculations.



### Legend

- Leucadia
- Old Encinitas

City of Encinitas - Leucadia Area Watershed Master Plan

**Vicinity Map**

**Figure 1-1**



Figure 1-2

## **2 PROJECT APPROACH AND DESIGN CRITERIA**

### **2.1 Background**

This study focuses on two specific areas or regions within the City of Encinitas, Leucadia and Old Encinitas. Historically, the City experiences most of its major recurring floods within the Leucadia area. To be precise, the majority of the extensive flooding issues occur within the areas of Leucadia, west of the I-5 Freeway, north of Encinitas Boulevard/B Street. Historical data research and coordination with City staff aided in developing more refined or focused boundaries to be evaluated. By refining the model boundaries, individual watersheds can be analyzed with more detail. Consequently, the Leucadia area was divided into four focused watersheds, and the Old Encinitas area was modeled as a single watershed.

The City of Encinitas (primarily Leucadia) has been subject to recurring flooding during moderate to extreme storm events. Encinitas became an incorporated City in 1986, and with it inherited the drainage infrastructure from the County of San Diego. Pre-incorporation, unfortunately, the community of Leucadia was not properly planned with regional flood control in mind. The area of Leucadia was nearly built out at the time of incorporation, and when incorporated the new City council actually proclaimed a no growth ‘moratorium’ discouraging new development within the City. New development typically is used as a financial mechanism to update or improve drainage infrastructure. As a result, any major storm drain improvements would need to be paid for by grants or fall on the burden of the City and the residents.

Flooding for the residents of Leucadia has become commonplace during moderate storm events. The current drainage infrastructure includes a small backbone pipe system, a manual sluice gate, a permanent pump station near Phoebe Street, mobile pumps, and temporary sand-bag revetment structures. The City and its residents have learned to cope with the current system, but not without recurring property damage and public safety concerns. To date, flood damage during storm events depends on the ability of City staff and residents to communicate and mobilize efficiently. Since storms can happen at any time, this means all parties involved must be available 24/7.

For example, the proper procedures for typical storm response involves keeping the sluice gate at RCP Block and Brick (577 N Vulcan Avenue) closed during storm events, flooding the Vulcan Avenue/Union Street area until the storm has subsided to not add to the flooding at the Leucadia Park area. Mobile pump systems are implemented at the park and discharge flows over the bluff. Other pump systems are deployed in around the Leucadia area where needed. Once the storm has passed, the sluice gate is opened to de-flood the Union Street area.

If one of these actions is not taken, or if the procedures are not made in the appropriate order, the result could be devastating with regards to flooding. If properly managed and enough resources are used at the right time, this system is an impressive flood control alternative for smaller storm events. Yet, a system with so many moving parts and reliance on attentive people with high knowledge of the system and proper processes, is subject to intermittent failure.

Multiple notable storm events have plagued Encinitas over the last 30 years. Two of the more recent notable storm events focused on in this study are listed below. These storm events were used in the model correlation, due to the number of documented photographs and videos that were available. The November 28, 2019 storm event was actually one of two sizeable events that occurred during the preparation of this study and provided valuable information for the correlation of the hydrologic/hydraulic models.

This “Thanksgiving Storm” was a short duration, high intensity storm that caused extensive flooding within the Leucadia area. Although the storm lasted over two days, the intensity for the first two hours was severe. This storm produced 0.9 inches in 30 minutes, which correlates to a 500-year (30-minute) storm event based on NOAA 14 Point Precipitation Frequency Estimates. Within an hour, 1.03 inches of rain was recorded, which correlates to a 100-year (1-hour) storm. For a 24-hour period, the storm produced 2.23 inches of precipitation, which correlates to a 12-year (24-hour) storm. The storm delivered a total of 2.64 inches within a two-day period. Over two (2) feet of ponding was witnessed at Leucadia Park and the surrounding areas. High intensity, short duration storms can overrun catch basin inlets, leading to excessive ponding. Although this storm did not produce extreme volume of runoff (as would the 100-yr (24-hour) storm would, it still caused surface flooding due to lack of surface drainage infrastructure.

Another relatively recent storm event that provided valuable information for model correlation was the December 12, 2014 storm. This storm brought increasing wind and precipitation with a period of heavy rain the morning of the 12th and showers continued into the following morning. Significant post-frontal showers occurred in San Diego County, as well as local convergence of air around coastal islands, producing a narrow band of showers. Widespread rainfall amounts of 1 to 1.5 inches were recorded in the coast and valley areas.

#### List of Previous Reports & Publications

Multiple studies have been prepared within the study area to address the local flooding within Leucadia, as well as regional systems within Encinitas. A list of some of these studies are below, including regional publications for drainage design guidance.

- Storm Drains in Leucadia, Final Report, San Diego County Grand Jury, 2012
- Hydrologic & Hydraulic Study for Coast Highway 101, Interim Storm Drain Improvements, Rick Engineering, November 2003
- Addendum to Hydrology and Hydraulic Study for Leucadia Drainage Improvement Alternatives, Rick Engineering, January 2005
- Hydrology & Hydraulics Study for Leucadia Drainage Improvement Alternatives, June 2004
- Cottonwood Creek/Moonlight Beach Facilities and Cost Benefit Analysis, Nolte Associates, May 2003
- San Diego County Enterococcus Regrowth Study, John Griffith, January 2012
- Cottonwood Creek & Moonlight Creek Capacity Evaluation, West Consultants, June 2005
- Cottonwood Creek Watershed LID Retrofit Plan, Tetra Tech, April 24, 2015
- Comparison of Gray versus Green Infrastructure Solutions for the Vulcan Avenue\Union Street\Orpheus Street\Encinitas Boulevard Drainage Improvements, Tetra Tech, December 2015
- Analysis for County of San Diego Rainfall Distribution Study Project, Bureau Veritas, March 2013
- San Diego County Hydraulic Design Manual, September 2014
- City of Encinitas Engineer Design Manual, BMP Design Manual, February 2016
- City of Encinitas, Final Climate Action Plan, January 2018
- Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions, California Region 18, USACE, July 2015

## 2.2 Study Area Watersheds

The study was broken up into two main areas, Leucadia, and the Old Encinitas (See Figures 2-1, and 2-2). The Leucadia area experiences the worst flooding conditions within the entire City. This area was further divided into four watersheds based on natural drainage patterns. The Leucadia watersheds west of I-5 include L101, Vulcan, and South Leucadia (South). One Leucadia watershed resides generally east of the I-5 and is referred to as East Leucadia (East).

Some of the area within the L101 and Vulcan watersheds contain local depressions that do not currently drain well via gravity. During large storm events, these depressions will fill and runoff will spill-over into the adjacent watershed through a process known as bifurcation. Consequently, drainage boundaries can change from one storm to another depending on the amount and intensity of precipitation. One of the most notorious depressions exist at Vulcan Avenue and Union Street.

Bifurcation and the ability to better understand surface flow behaviors was one of the reasons the City of Encinitas requested the use of an advanced stormwater model to analyze these areas. The following drainage subareas were developed for analysis using XPSwmm.

### 2.2.1 Leucadia Focused Subareas

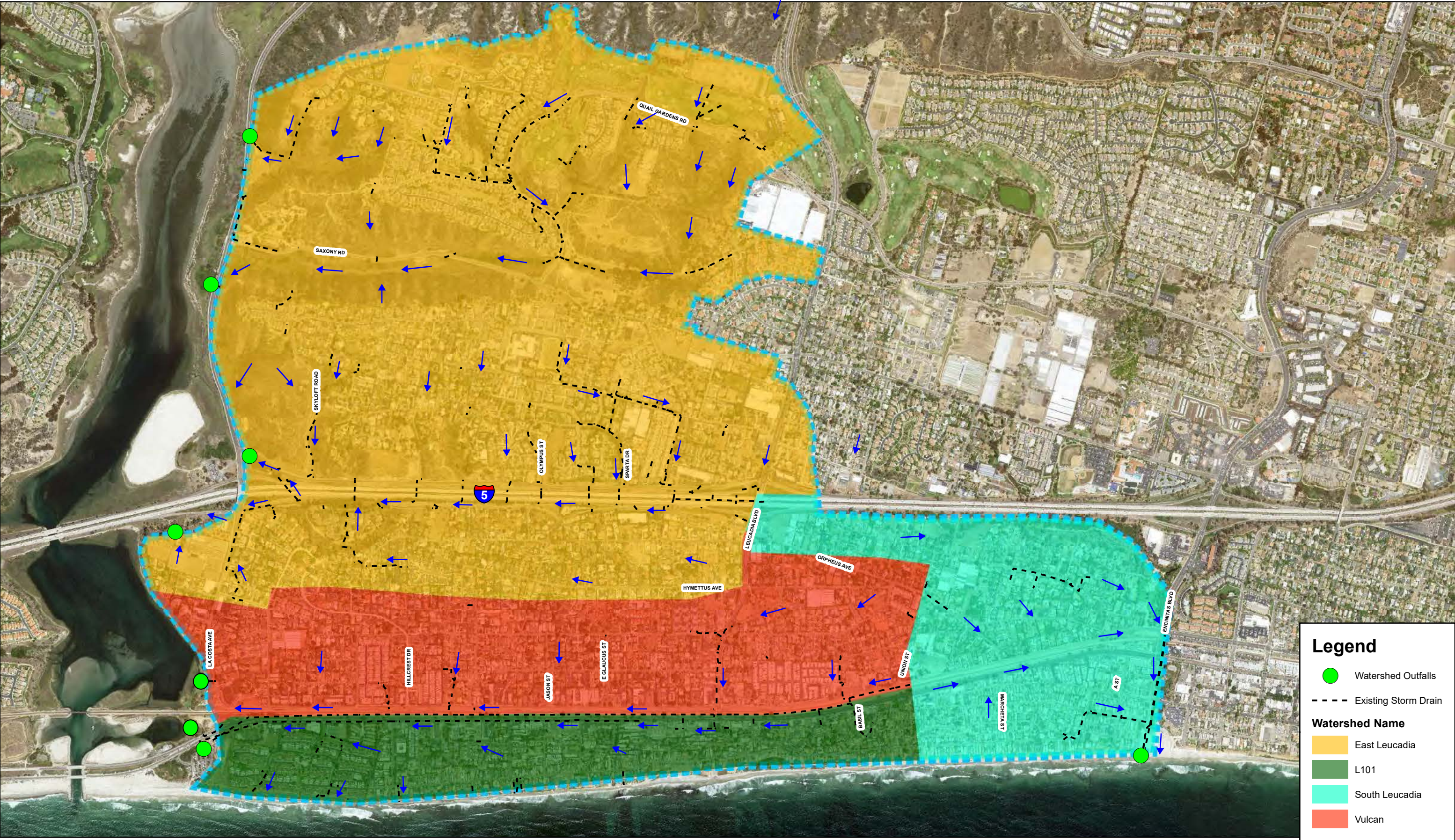
#### Leucadia 101 Subarea (L101)

The L101 watershed is approximately 200 acres (green area in Figure 2-1). This area is currently being improved by the City and is known as the North Coast Highway 101 Streetscape (or L101 Streetscape) project. The L101 subarea includes the part of the L101 Streetscape project bound by the NCTD railroad tracks (to the east), the ocean to the west, El Portal Street to the south, and South Ponto Beach to the north. The stormwater runoff from this watershed generally drains towards the North Coast Highway (L101), where it is conveyed north to the South Ponto Beach basins. Currently, this watershed experiences some of the most extensive flooding of any watershed in the City, as North Coast Highway resides in a small valley within the Leucadia area.

The L101 subarea contains several low spots or depressions that have a tendency to flood, even during moderate storm events. This area contains minor storm drain infrastructure, which includes a small storm water pump station at Phoebe Street and two low-flow storm drain systems. This system was designed as a non-storm water flow (nuisance flow) system, with the goal to alleviate some of the flooding associated with small storm events (i.e. 1- to 2-year events). A 24-inch reinforced concrete pipe (RCP) extending from Basil Street north to the Ponto Beach basins was constructed in 2001, and later refined in 2005 to help alleviate some of the known flooding along North Coast highway, including a portion of area east of the NCTD railroad tracks along Vulcan Avenue, near Union Street.

A second (older) storm drain, an 18-inch concrete pipe (CP), extends from Diana Street, travels north along the southbound lanes to the South Ponto basins. A Closed-circuit television (CCTV) inspection was performed as part of the utility research in North Coast Highway showed this system runs parallel to the 24-inch RCP and contains multiple connects with the 24-inch storm drain. The 18-inch CP intercepts runoff from the west side of North Coast Hwy and is connected to the Phoebe Street pump station as well as the 24-inch RCP. The pipe system extends north to the Ponto Beach basins discharging through a shared headwall with the 24-inch RCP.

The 24-inch RCP also is used to drain a portion of the area east of the NCTD railroad tracks near the Union Street/Vulcan Avenue area. A sluice gate at the upstream end, controls the flows from the Vulcan/Union area to the downstream system. The gate is typically set to the “closed” position during storm events. Past experience revealed that when allowed to flow freely, the excess flows would overburden downstream system, limiting the downstream facilities ability to drain. During medium and large storm events (larger than a 5-year/24-hour storm), the system would surcharge at several locations.



**Legend**

- Watershed Outfalls
- - - Existing Storm Drain

**Watershed Name**

- East Leucadia
- L101
- South Leucadia
- Vulcan

The sluice gate is manually controlled by the City and is intended to drain the Vulcan/Union area after a storm has subsided.

Even with the sluice gate closed, the current storm drain system is too small to handle moderate to large storm events. Prior to the construction of the 24-inch storm drain system, previous studies revealed a much larger system was needed to mitigate the 100-year storm event. Primarily due to environmental constraints at the outfall (Ponto Beach basins), the maximum pipe size allowed by the regulatory agencies at the time was 24-inches.

Multiple locations within the L101 subarea are notorious for flooding. Some of the most problematic are listed below:

- Leucadia Roadside Park and surrounding areas
- Basil Street
- Hwy 101 – northbound shoulder (multiple locations), and
- Hwy 101 at Phoebe Street and adjacent areas.



*Back Alley Near Leucadia Park, November 28, 2019*

The L101 watershed is also subject to bifurcation from the Vulcan watershed to the east. During large storm events (greater than a 25-year/24-hour), it has been noted by City staff (and collaborated in the hydraulic models here within) that flows from the Vulcan watershed area pond and eventually bifurcate, discharging additional flow into the L101 watershed through the railroad ballasts. Two of the main locations where this occurs is near Leucadia Boulevard, and near Jason Street.

### Vulcan Subarea

The Vulcan subarea is approximately 380 acres (red area in Figure 2-1). The subarea is located east of the NCTD railroad tracks and is generally bound by Hymettus Avenue to the east, the NCTD railroad to the west, Orpheus Avenue to the south, and La Costa Avenue to the north. This watershed generally drains from south to north along Vulcan Avenue where it discharges into the Batiquitos Lagoon north of the intersection of La Costa and North Vulcan Avenue.

Similar to the L101 subarea, the Vulcan area resides in a valley and contains several low spots or depressions that have a tendency to flood, even during moderate storm events. One of the most flood prone locations is at the afore mentioned Union Street and Vulcan Avenue. Local storm drains feed into the L101 area via the 24-inch pipe just upstream of the sluice gate. Since this gate is closed during storm events, much of this area does not have a storm drain outlet and experiences severe flooding until the gate is opened and the area can be drained.

Within the watershed, several minor storm drains have been constructed to mitigate locations prone to flooding within sump areas. Most of the streets east of Vulcan Avenue were not constructed with curb and gutter. As a result, flowing runoff from storm events become difficult to control. Some sump areas have been retrofitted with dry wells, which provide some protection during small storm events but are overburdened during medium to large storm events.

The Vulcan watershed contains several known areas prone to flooding. Some of these areas include:

- Vulcan Avenue at Union Street
- Orpheus Avenue (Orpheus Lake)
- Hymettus Avenue
- Fulvia Street
- Hermes Avenue north of Leucadia Blvd.
- Glaucas Street, and
- Vulcan Avenue (multiple locations).

The flooding at Orpheus Avenue, commonly referred to as “Orpheus Lake” is actually at the watershed boundary between the Vulcan and South Leucadia drainage areas.

The City recently constructed some improvements near this location as part of a pedestrian crossing project.

These improvements were not a part of the “existing condition” analyses for this area. But, the project is not expected to change the regional flooding conditions at this site.



*Vulcan Avenue/Union Street: December 12, 2014*

#### South Leucadia Subarea

The South Leucadia subarea is approximately 130 acres (turquoise area in Figure 2-1). The subarea is located just south of both the L101 and Vulcan subareas. It is generally bound to the east by Ocean Avenue, to the west by the ocean, and south at Encinitas Blvd. This area drains north to south, eventually discharging into Cottonwood Creek and Moonlight Beach. Currently, a portion of this area drains to a low point along Vulcan Avenue, just south of Union Street. As previously discussed, the 24-inch sluice gate allows for this ponded runoff to drain towards Ponto Beach after storm events.

This watershed contains several “dry-well” type inlets focused on draining surface flows via infiltration. The South Leucadia watershed contains the following known flooded locations:

- Portion of the Orpheus Avenue (Orpheus Lake).
- Intersection of Orpheus and Vulcan.
- Along Vulcan Avenue between Sunset Drive and Orpheus Avenue; and
- Intersection of Sylvia Street and 4<sup>th</sup> Street.

Some minor storm drain systems exist within this subarea. Most of these drainage systems tie into portions of Cottonwood Creek under B Street prior to discharging at Moonlight Beach. The downstream portions of Cottonwood Creek, generally between 3<sup>rd</sup> Street and Moonlight Beach are known to flood during very large storm events, causing sheetflow to travel westerly along B Street and discharge at Moonlight Beach.

This system was constructed by the U.S. Army Corps of Engineers (USACE) and the County of San Diego. No proposed improvements will be recommended for this channel as part of this study. Rather, flows, normally tributary to this system within the South Leucadia subarea, could be captured and routed in a separate, parallel system and discharged at the same location along the beach. As identified in previous studies, adding additional flows into Cottonwood Creek would adversely impact an already undersized system. It would also be subject to Drainage Law and potentially diverting of flows from one watershed to another.

### East Leucadia Subarea

The East Leucadia Subarea is located east of the Vulcan Subarea and is generally bound by Hymettus Avenue to the west, Leucadia Blvd. to the south, El Camino Real to the east and Batiquitos Lagoon to the north. This watershed contains three main outfalls that all drain to the Batiquitos Lagoon. Figure 2-1 (yellow area) shows the extents of the watershed.

This watershed does not contain any major known recurring flood locations. One location that experiences moderate flooding is at Urania Avenue near Brittany Avenue. More than half of the watershed drains towards the I-5 in a network of storm drains that eventually discharges under La Costa Avenue into Batiquitos Lagoon through a series of culverts.

#### **2.2.2 Old Encinitas Focused Area**

The old Encinitas area is defined by the region south and south/east of the Leucadia area and can be seen in Figure 2-2. Most of the area (approximately 1,550 acres) resides east of the I-5, south of Leucadia Blvd., and west of Garden View Road and Via Canebria. Approximately 400 acres of the area also extends west of the I-5 to the ocean, south of Encinitas Blvd., north of Santa Fe Drive. The majority of the Old Encinitas area drains to Cottonwood Creek, and eventually Moonlight Beach. Figure 2-5 shows the extents of the watershed.

This watershed has not historically experienced major flooding but does experience localized flooding along some of the streets. Examples of some of the locations are shown below:

- South Vulcan Avenue at F Street; and
- South Vulcan Avenue just south of D Street.

### **2.3 Design Criteria**

The hydrology and hydraulic criteria for the design of storm drain systems is based on County of San Diego guidelines. In general, the hydrology guidelines are stated in the San Diego County Hydrology Manual.

Hydrology for this project was prepared in accordance with the County Hydrology Manual guidelines to calculate the loss rates. The evaluation and preliminary design of drainage infrastructure was based on the 1-percent annual chance (100-year) storm event.

At the time of this study, the County of San Diego was in the process of making a policy change to use more recent rainfall data than what was currently in the Hydrology Manual. Consequently, the City requested rainfall data be taken from the more recent version of the National Oceanic and Atmospheric Administration (NOAA) atlas for precipitation frequency estimates (NOAA Atlas 14).

Public streets typically are to be designed to contain a 10-year storm event within the top of curb of the street section. Larger streets will contain a minimum of one dry lane in each direction. The 100-year 24-hour event shall be contained within the City's right-of-way, with a minimum of one (1) foot of freeboard to the adjacent pad elevations.

#### **2.3.1 Design Constraints**

##### Surface Drainage Characteristics

Throughout much of the older Leucadia watersheds, there is a lack of traditional flood control infrastructure. Multiple low points within the watershed collect stormwater runoff, where it either ponds, travels through, or around, properties to downstream low points, or in some cases is collected in drainage systems to be percolated via dry wells.

Many of the streets within the Leucadia watershed contain no curb and gutter. In some cases, small earthen or vegetated earthen berms were constructed to convey stormwater runoff to, in many cases to

these low points. Many Leucadians prefer the appearance of curb-less streets, as suggested in a public Open House event held at the City in September of 2019.

Curb-less streets create a design constraint as to how to collect and convey stormwater runoff efficiently. A solution must be developed that can minimize runoff (where possible) and identify safe flood routing and capture alternatives.

Many of the streets in these areas contain earthen (dirt) shoulders that residents currently use for overflow vehicular parking. These earthen shoulders could potentially be used for green infrastructure, such as bioswales or biostrips, or pervious pavement. Yet, these facilities typically contain construction footprints that would extend beyond the footprint of the existing earthen shoulder, which would eliminate any potential vehicular parking. Implementation of green infrastructure in these areas should consider a dual use solution, allowing for potential parking areas.

#### Regional Stormwater Discharge Regulations

This study contains four (4) receiving water bodies where all stormwater runoff within the Leucadia and Old Encinitas areas discharge to: Batiquitos Lagoon; directly to the ocean; Moonlight Beach (either directly or via Cottonwood Creek); and the groundwater via infiltration.

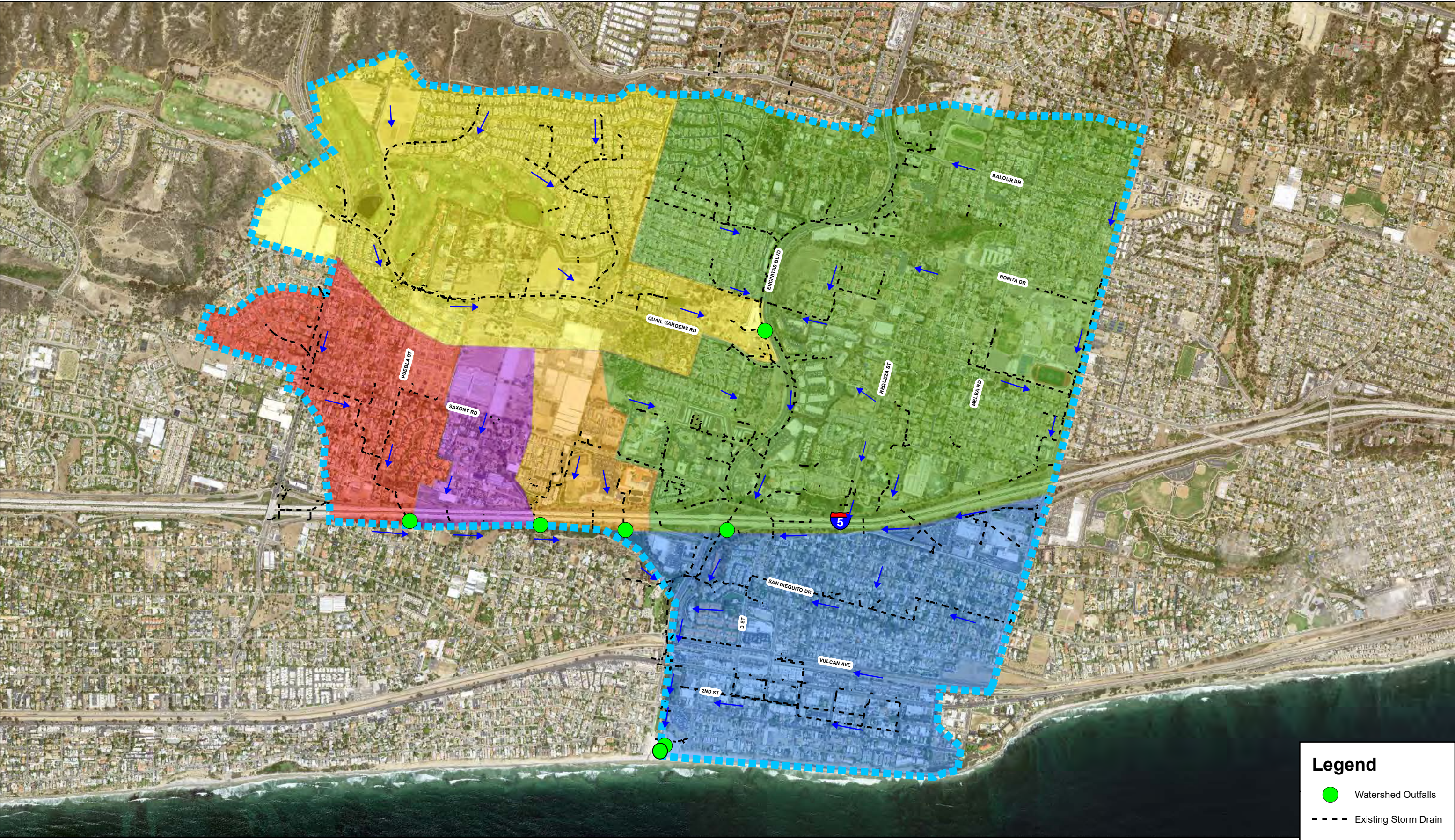
Batiquitos Lagoon currently is the receiving stormwater runoff from most of the Leucadia watershed north of Encinitas Boulevard and a portion of the Union St./Vulcan Ave. sump area. Two existing storm drain systems discharge flows near Ponto Beach (an 18-inch and a 24-inch). These systems drain runoff from the Leucadia 101 subarea. Both systems discharge into a vegetated channel that lies between the Ponto Beach parking lot and North Coast Highway. This channel conveys flows north into a series of basins, ultimately discharging to the west portion of the Batiquitos Lagoon between the North Coast Highway and the railroad tracks. Another 24-inch outlet drains a small area near the North Coast Highway and La Costa Avenue intersection. This outlet also is located between the North Coast Highway and the railroad tracks.

East of the I-5 Freeway, the Encinitas Creek channel parallels the freeway draining a major portion of the Leucadia East watershed. The channel discharges into the Batiquitos Lagoon just northeast of the La Costa Avenue offramp. The easternmost side of the Leucadia East watershed drainage into the Batiquitos Lagoon via storm drains under La Costa Avenue near Saxony Road.

Several agencies have jurisdiction within the areas adjacent to the Batiquitos Lagoon. In particular, the San Diego Regional Water Quality Control Board (RWQCB), United States Army Corps of Engineers (USACE), California Fish and Wildlife (CFW), and the California Coast Commission (CCC). Special considerations and extensive coordination will need to occur during the final design phase of any proposed alternative project that disturbs the area. Focus will need to be applied to water quality, impacts to species, and impacts to the lagoon ecosystem. In 2003, the City proposed a flood control project to construct a nine (9) foot diameter storm drainpipe, that discharged into the lagoon. This project was denied by these agencies and resulted in restricting the pipe to no larger than a 24-inch outlet at the Ponto Beach basins. Early coordination with the reviewing agencies will be key in implementing a final design and potential construction of any flood control improvements that discharge into the Batiquitos Lagoon.

South Leucadia and much of Old Encinitas watersheds currently drain into Cottonwood Creek, which discharges to Moonlight Beach. Cottonwood Creek's tributary drainage area is approximately 3.1 square miles collecting runoff from mostly urbanized area.

Cottonwood Creek currently has a water quality treatment and pump station located at 3<sup>rd</sup> Street and B Street that directs a portion of the dry weather, or nuisance, flows from Cottonwood to an ultra-violet (UV) treatment facility. This flow is then pumped to the Encina Sanitary District treatment facility.



**Legend**

- Watershed Outfalls
- Existing Storm Drain

Stormwater runoff from the Cottonwood Creek discharge at Moonlight Beach. The existing Cottonwood Creek outlet to Moonlight Beach consists of three (3) corrugated metal pipe (CMP) arches and one 10' x 4' reinforced concrete box (RCB). The RCB transitions into a dual pipe outlet at Moonlight beach adjacent to the triple arch culvert. These outlets have been subject to coastal erosion and are currently in need of repair. Loose riprap covers the double pipe outlet, and cracked and spalling concrete are noticeable on the triple arch culvert headwall. Improvements to this facility will require California Coastal Commission approval. Any modification will also be subject to RWQCB, CDFW, and USACE.

Several impairments exist within the four general stormwater outlet locations. Table 2-1 shows the location and current impairment. Moonlight Beach, near the Cottonwood Creek outlet is the only location where there is a listed impairment with a TMDL (Indicator Bacteria).

**Table 2-1. Receiving Water Body Water Quality Impairments**

| Receiving Water Location | Impairment   | TMDL                     |
|--------------------------|--|--------------------------|
| Batiquitos Lagoon        | Listed for Toxicity  | No                       |
| Moonlight Beach          | Listed for Indicator Bacteria, Trash   | Yes (Indicator Bacteria) |
| Cottonwood Creek         | Listed for DDT, Nitrogen, Benthic, Community Effects, Phosphorus, Selenium, Toxicity | No                       |
| Encinitas Creek          | Listed for Phosphorus, Toxicity, Selenium, Benthic Community Effects                 | No                       |

## 2.4 Data Research

The data research and acquisition process included coordination with County and City staff and field review. The goal of the research was to identify all available data, including previous drainage related studies, drainage related as-built plans, and information regarding previous flooding issues. Items acquired included the following:

- Storm Drain As-Built
- Previous Drainage Studies
- Storm Drain Maintenance Notes (based on discussion)
- Field Drainage Facility & Site Investigations
- Historical Rain Gage Data
- Historical Storm Photos and Videos
- Available Survey & Topographic Data
- Land Use Data
- Soil Data
- Bluff Stability Reports/Research
- Water Quality Data and Requirements
- Batiquitos Lagoon Research
- Moonlight Beach Research
- Encina and Cardiff POTW Plans and Operation
- SEJPA Plans for Water Quality
- NOAA Atlas 14 Precipitation Data

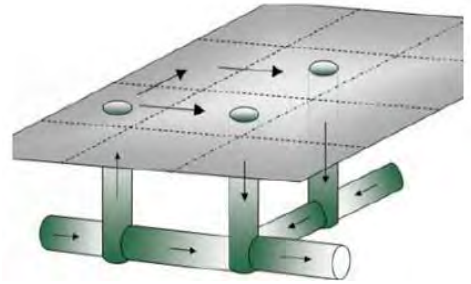
The data acquisition and review process was used to establish the existing conditions model, which requires the most time and effort. It was also used to help establish goals for the proposed drainage infrastructure.

A majority of the data was taken from the City's current GIS database. Some storm drain data needed to be updated for modeling purposes. For modeling, it is important that all drainage (line work) is connected or joined. This is not necessary for purposes of showing systems on a GIS database.

## 2.5 Technical Software Description

This study was performed using an advance hydrologic and hydraulic modeling approach because of the area's unique hydrologic and drainage characteristics. The city contains many large flat areas with minimal drainage infrastructure. Drainage relies on surface flows through streets and between properties and in many cases drains to sumps or low points within the City. These conditions typically contain high tailwater controls and require stormwater runoff volume accounting, as the sumps fill up and can bifurcate to adjacent sub watershed.

Innovyze's XPStorm software model was used to link both the hydrology and hydraulic simulations. XPStorm solves the full St. Venant Equations. In other words, the program solves the highest level of computation available for regional storm drain modeling. The model utilizes full rainstorm patterns, not just peak flows, to calculate expected runoff and storm drain capture and conveyance efficiencies. Surface flow hydraulics are evaluated in two-dimensions (2D) based on a 3D surface or digital terrain model (DTM). A link is created between the surface hydraulics and the subsurface (storm drain) hydraulics. The result is a comprehensive and more realistic analysis of the entire drainage system.

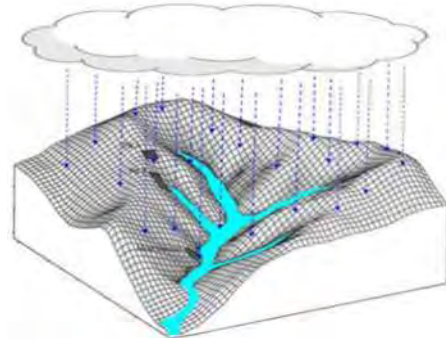


*XPStorm Links Surface (2-D) to Subsurface (1-D)*

## 3 HYDROLOGY

### 3.1 Methodology

The hydrology was prepared in accordance with the San Diego County Hydrology Manual (SDHM), and NOAA Atlas 14 for the 1-percent annual chance storm events (24-hour duration). Initially, an existing watershed model was prepared to create a baseline for future potential improvements. Once a baseline was developed, multiple alternative “improvements” were evaluated and compared to the baseline conditions to identify the impacts of these improvements on the study area. XPStorm allows the user to evaluate the impacts of proposed improvements. Several proposed improvements can be performed simultaneously, resulting in a great tool to focus in on the most effective solution.



*Distributed Rainfall Method (Rain-on-Grid)*

This study focuses on regional solutions targeted at identifying how to eliminate the flooding within the City during major storm events (i.e. 25-year or greater). This study does not focus on small or “local” improvements that may slightly reduce existing flooding.

The hydrology for the model was divided into multiple subareas as discussed previously. All areas within the focused study area were evaluated in XPStorm using the rain-on-grid, or Direct Rainfall Method (DRM). DRM is the process of adding rainfall directly to the three-dimensional surface, or digital terrain model. This method allows the surface’s physical characteristics (i.e. topography, land use, and surface friction) to dictate the flow patterns, resulting in a more realistic rainfall-runoff modeling approach. Figure 3-1 shows the areas where DRM rainfall patterns were used based on the land uses.

For a given area, DRM will yield different peak flow runoff values than the standard Unit Hydrograph method approach. This is a result of the response of the runoff on the 3D surface. Theoretically, the peak flows produced by a Unit Hydrograph are calculated based on time-of-concentration (or lag), which assumes all flows are fully concentrated and conveyed from one concentration point to the next. This process has the tendency to reduce travel time, resulting in produce higher peak flow rate estimates. The DRM method will produce more realistic runoff patterns and values. DRM in conjunction with XPStorm’s dynamic wave hydraulic calculation routine will yield more accurate pipe sizes as well, when reviewing solutions for currently flooded areas.

In the absence of stream gage information, the 2D maximum depth results were correlated to photographic and video footage of known storm events. Specific storm precipitation data was acquired from the local rain gage and used in the model. The local rain gage is ENCC1 Alert #2, located near Lake Drive and Woodlake Drive intersection. Known areas of flooding were compared to photographic evidence of maximum flood depths.

### 3.2 Precipitation

The DRM data was prepared using the San Diego County Hydrology rainfall pattern to develop hyetographs. The point precipitation data for the 100-year storm event (or 1% annual chance of exceedance) was based on the NOAA Atlas 14 data for the Leucadia/Old Encinitas area. The data was compiled in GIS to yield area-weighted rainfall values throughout the City. The average gross (before reduction) precipitation values for the 100-year storm event are displayed in Table 3-1.

For any 2D model, there are two methods for extracting “losses” in the runoff. One method is to use surface infiltration with methods such as Green-Ampt, which extracts runoff from the 3D surface. This

method is commonly used in rural watershed analyses as most of the surface is no impermeable. Another method, more commonly used in urban stormwater modes is to derive a “net” rainfall by manually extracting the losses out of the rainfall prior to discharging to a 3D surface. This method allows the user to utilize local hydrology criteria (loss rate calculations). The “net” rainfall varies based on land use and soil characteristics. The more impervious a particular area is, the higher the net rainfall. The breakdown of land uses were based on the NRCS land use types, as they are more detailed than those listed in the SDCHM. The SDCHM land uses are a more generalized version of the NRCS land uses.

**Table 3-1. Average Gross 100-Year Point Precipitation Data (NOAA 14)**

| Duration | Point Precipitation |
|----------|---------------------|
| 5-min    | 0.31                |
| 30-min   | 0.76                |
| 60-min   | 1.07                |
| 3-hr     | 1.70                |
| 6-hr     | 2.25                |
| 24-hr    | 3.77                |

### 3.2.1 Land Use Designations

The land use data was acquired from the City General Plan. Figure 3-1 shows the designations throughout the study area, which is generally identified within the dashed polygon. The study area is currently built-out. As a result, “existing land use” and “future land use” will not have much variation. Consequently the land use parameter was not changed in the “project conditions” models.

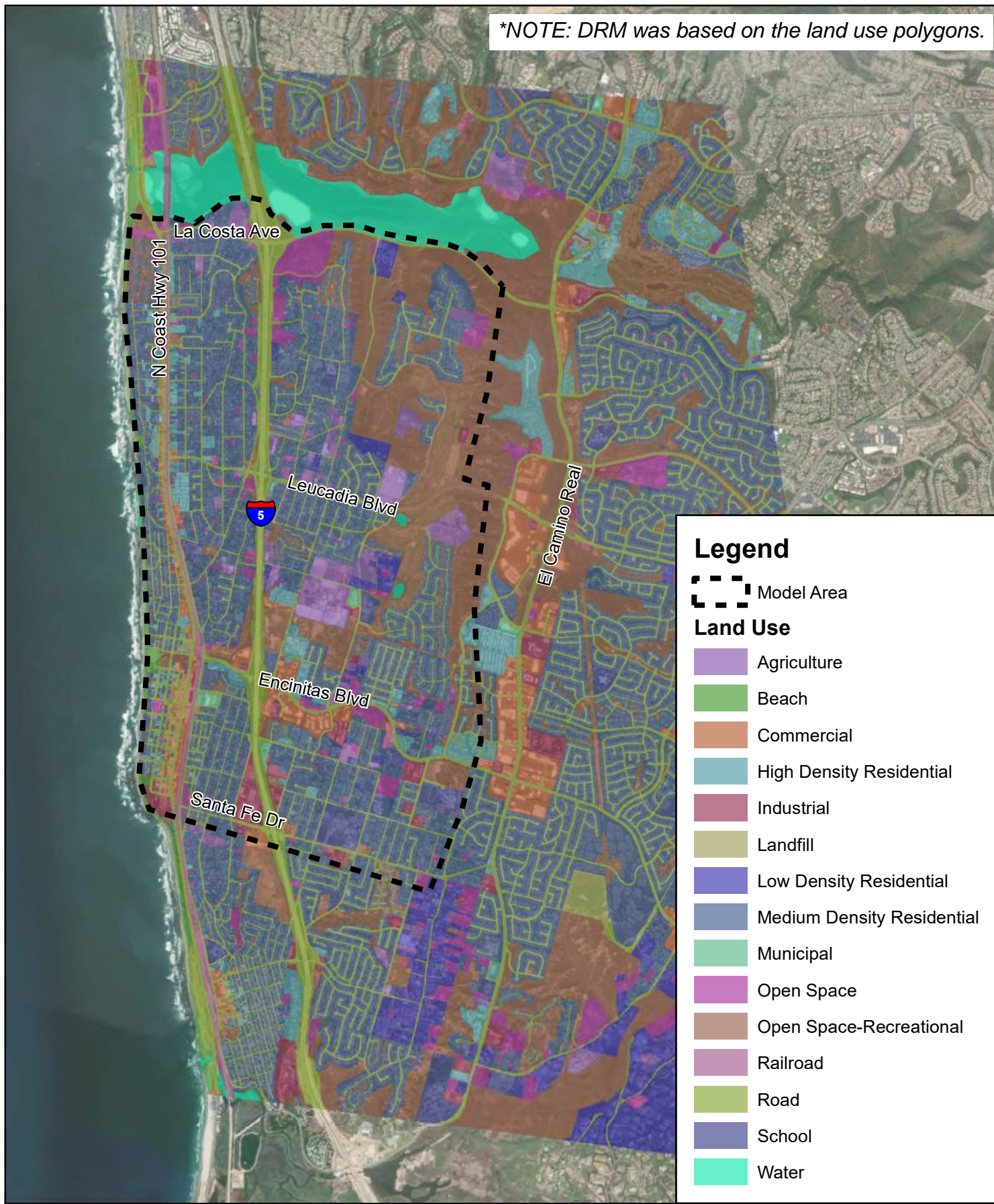
### 3.2.2 Soil Type

The hydrologic soil data was acquired from the Natural Resource Conservation Services (NRCS) web soil survey. Figure 3-2 shows the soil designations (hydrologic soils) within the study area.

## 3.3 Loss Rate Calculations

Loss rates for the DRM hyetographs were calculated based on the methods prescribed in the San Diego County Hydrology Manual and the NRCS. Runoff factors, or Curve Numbers (CN) were taken from NRCS, as they expand beyond the land uses used in the SDHM (i.e. more detail). To incorporate the losses in the rainfall, a “net precipitation” is calculated to then be used in the DRM. Loss rates were calculated and incorporated into the rainfall point precipitation depths based on Land Uses, Soil Type, and using Precipitation Zone Number (PZN) equal to 2. Table 3.2 shows the categories used to assign land uses within the study area.

*\*NOTE: DRM was based on the land use polygons.*



## Legend

Model Area

### Land Use

- Agriculture
- Beach
- Commercial
- High Density Residential
- Industrial
- Landfill
- Low Density Residential
- Medium Density Residential
- Municipal
- Open Space
- Open Space-Recreational
- Railroad
- Road
- School
- Water

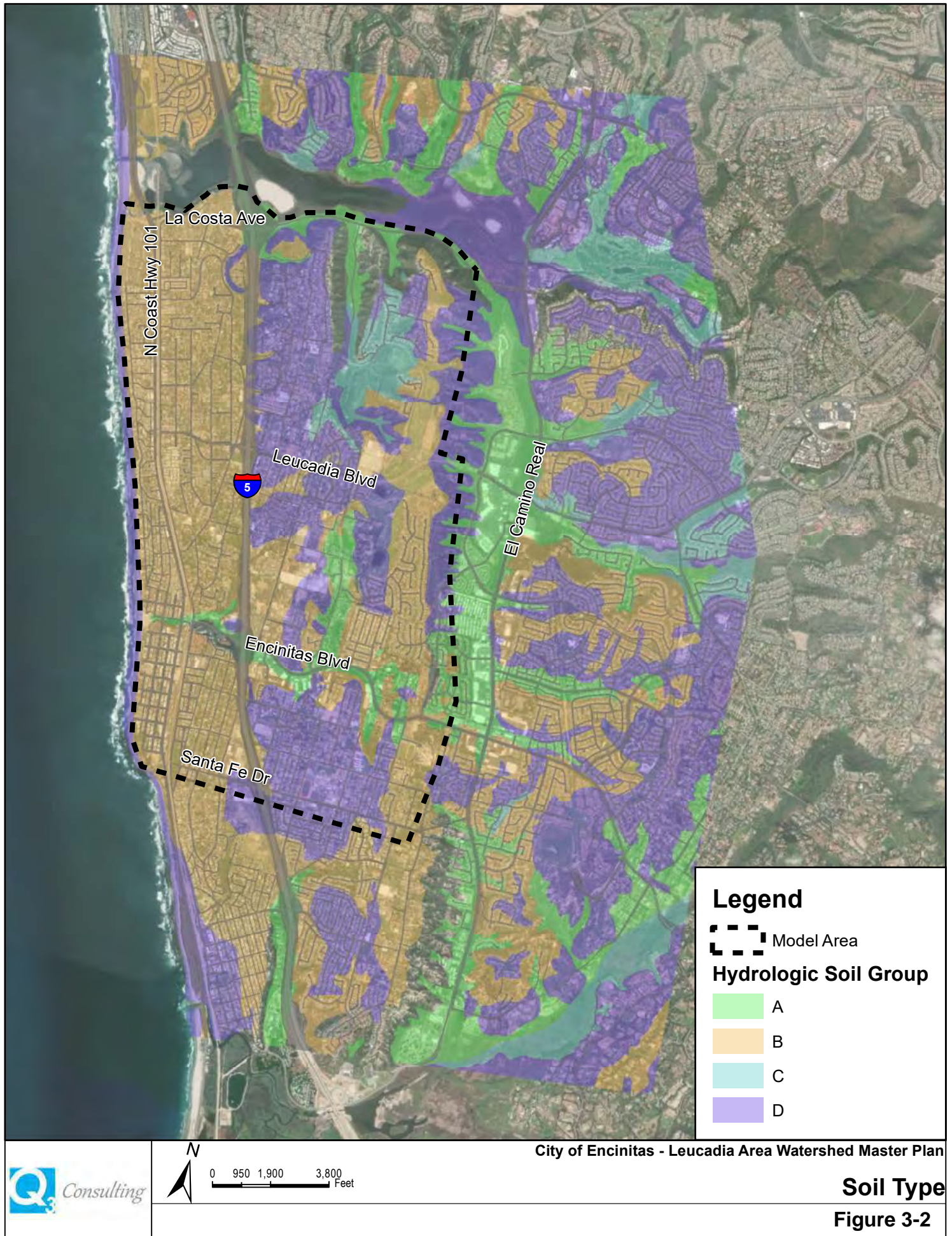


Table 3-2. Land Use Curve Number Data (PZN 2)

| Land Use Description                                | Code     | %IMP | Hydrologic Soil Group |    |    |    | Cover Type              |
|---|----------|------|-----------------------|----|----|----|-------------------------|
|   |          |      | A                     | B  | C  | D  |                         |
| Rural Residential, 0 to 0.25 du/ac                  | RRFP     | 10   | 45                    | 64 | 77 | 82 | residential district    |
| Rural Residential, 0.25 to 0.5 du/ac                | RR       | 15   | 48                    | 66 | 78 | 83 | residential district    |
| Rural Residential, 0.5 to 1 du/ac                   | RR1      | 20   | 51                    | 68 | 79 | 84 | residential district    |
| Rural Residential, 1 to 2 du/ac                     | RR2      | 25   | 54                    | 70 | 80 | 85 | residential district    |
| Residential, 2 to 3 du/ac                           | R3       | 30   | 57                    | 72 | 81 | 86 | residential district    |
| Residential, 3 to 5 du/ac                           | R5       | 40   | 61                    | 75 | 83 | 87 | residential district    |
| Residential, 5 to 8 du/ac                           | R8       | 50   | 67                    | 79 | 86 | 89 | residential district    |
| Residential, 8 to 11 du/ac                          | R11      | 60   | 74                    | 83 | 89 | 91 | residential district    |
| Residential, 11 to 15 du/ac                         | R15      | 65   | 77                    | 85 | 90 | 92 | residential district    |
| Residential, 15 to 25 du/ac                         | R25      | 80   | 77                    | 85 | 90 | 92 | residential district    |
| Mobile Home Park                                    | MHP      | 75   | 77                    | 85 | 90 | 92 | residential district    |
| Office Professional                                 | OP       | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| Local Commercial                                    | LC       | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| General Commercial                                  | GC       | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| Visitor Serving Commercial                          | VSC      | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| Light Industrial                                    | LI       | 72   | 81                    | 88 | 91 | 93 | industrial              |
| Public/Semi-Public                                  | P/SP     | 15   | 49                    | 69 | 79 | 84 | open space fair         |
| Transportation Corridor                             | TC       | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| Ecological Resource/Open Space/Park                 | ER/OS/PK | 10   | 49                    | 69 | 79 | 84 | open space, fair        |
| agriculture   | AG       | 10   | 59                    | 74 | 82 | 86 | farmsteads              |
| business park                                       | BP       | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial  | C        | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| civic center  | CC       | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| general commercial                                  | C-GC1    | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| general commercial                                  | C-GC2    | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial mixed                                    | CM-1     | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial mixed                                    | CM-2     | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial mixed                                    | CM-3     | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial office professional                      | C-OP     | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial residential mixed                        | C-R11    | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial residential mixed                        | CRM-1    | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| commercial residential mixed                        | CRM-2    | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| agriculture lab                                     | ER-P/SP  | 10   | 59                    | 74 | 82 | 86 | farmsteads              |
| general commercial - planned commercial development | GC-PCD   | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| historic park                                       | HP       | 10   | 49                    | 69 | 79 | 84 | open space, fair        |
| limited local commercial                            | LLC      | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| limited visitor serving commercial                  | LVSC     | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| Moonlight Beach Park                                | MBP      | 10   | 49                    | 69 | 79 | 84 | open space, fair        |
| mixed use   | MU1      | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| mixed use   | MU2      | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| neighborhood park                                   | NP       | 10   | 49                    | 69 | 79 | 84 | open space, fair        |
| office mixed  | OM       | 85   | 89                    | 92 | 94 | 95 | commercial and business |
| open space  | OS       | 10   | 49                    | 69 | 79 | 84 | open space, fair        |
| residential, maximum 20 du/ac                       | R20      | 80   | 45                    | 64 | 77 | 82 | residential district    |
| residential, maximum 4 du/ac                        | RS11     | 40   | 45                    | 64 | 77 | 82 | residential district    |
| residential, maximum 3 du/ac                        | SFR3     | 30   | 45                    | 64 | 77 | 82 | residential district    |
| residential, maximum 3 du/ac                        | SFR3V    | 30   | 45                    | 64 | 77 | 82 | residential district    |
| residential, maximum 5 du/ac                        | SFR5     | 45   | 45                    | 64 | 77 | 82 | residential district    |
| special purpose/home depot/open space               | SPA      | 10   | 49                    | 69 | 79 | 84 | open space, fair        |
| visitor serving commercial                          | VCM      | 85   | 89                    | 92 | 94 | 95 | commercial and business |

## 4 FLOOD ROUTING ANALYSES

### 4.1 Methodology

The study area was modeled using XPStorm, which is an improved version of the U.S. EPA's Storm Water Management Model (SWMM). XPStorm is a dynamic wave model that solves the full St. Venant Equations. Dynamic modeling allows the effects of storage and backwater in conduits and floodplains and the timing of the hydrographs to yield a true representation of the hydraulic conditions. XPStorm can model the surface in 2-dimensions, while linking to the subsurface infrastructure, or storm drain system. The result is a comprehensive model that can communicate between the surface and subsurface facilities throughout the modeled design storm duration.

Due to the topographic and climatic characteristics of this region, this project study benefited from an advanced surface model which identifies flow quantity and direction as it moves through the urban area. Traditional hydraulic modeling techniques that utilize steady-state flows and based on simplified flow equations (as was used in previous studies in Encinitas), cannot accurately predict the existing flood potential or the impacts of proposed improvements for these areas. Using advanced modeling techniques, hydraulic analyses were completed for both existing and proposed conditions with a linked 2-dimensional surface model, and 1-dimensional subsurface model (1D/2D) in XPStorm. The main existing City storm drain systems were added to a 3-dimensional surface terrain model to understand the level of flooding and to help identify what potential solutions could be implemented.

#### 4.1.1 Topography

Quality representative topographic data is critical for developing advanced stormwater models. The quality of the surface hydrology and hydraulics is dependent on the resolution and representation of existing features. Surface feature definition is even more critical for the City of Encinitas due to the lack of curb and gutter, which causes flows to travel through some properties rather than down streets.

The City of Encinitas is considered mostly developed, meaning, no major changes in land use or topography are expected in the future. Future land use changes are not likely to greatly impact the current plan or runoff patterns. Consequently, current topographic information may provide relevant depictions of surface features for time to come. The topography for the drainage models were based on LiDAR data acquired from the County of San Diego, flown between 2014 and 2015. This data was used to develop a 3-dimensional surface of the entire study area using 1-meter resolution data.

Some street areas had to be field verified for drainage features. For example, the reach along Orpheus Avenue known to flood (Lake Orpheus), contains earthen berms on both sides of the street. These features did not show up on the LiDAR data and had to be manually input into the surface.

#### 4.1.2 Vertical Datum

The project uses the North American Vertical Datum of 1988 (NAVD88). Several of the City as-built plans had to be revised from NGVD 29 to NAVD88. The conversion factor was identified as +2.16 feet. This adjustment was added to all elevations identified in as-built facilities prepared with the older datum.

#### 4.1.3 1-D Model Geometry

The geometry for existing storm drain systems were modeled as 1D elements within XPStorm and linked to the 2D interface grid. The geometries were obtained from As-built drawings and supplemented with field inspections. Many of the as-built data had to be adjusted for vertical datum.

#### 4.1.4 Manning's "n" Value

A varying manning's roughness value was used for the model. The manning's designations were as follows:

0.06 – Open Space

0.045– Residential/Commercial Landscaping

0.025 - Streets

Blocked– buildings/obstructions were not modeled with a Manning’s roughness.

For 2D modeling, the roughness coefficients are higher than standard drainage conduit values. The primary reason is, flows are generally shallow on 2D surfaces, therefore roughness is relatively more impactful on flows regimes.

#### **4.1.5 Grid Size**

The grid cell resolution is an important consideration in two-dimensional modeling. Small grid cell sizes increase accuracy, but require additional computation times, while larger grid sizes compromise accuracy but increase computation time. The determination of grid size requires a trade-off to ensure a workable model without compromising satisfactory accuracy.

Multiple cell sizes can be specified within one model, allowing a larger grid size to be used in areas where high detail is not required and a smaller grid size to be used in primary areas of interest. Multiple cells sizes were evaluated, and a 7.5-foot grid cell size was used for the Leucadia area models. This cell size was sufficient to adequately capture the street flow conveyance and refined enough to provide a higher level of detail in areas where bifurcation could be present.

#### **4.1.6 Computational Time Step**

The computational time step is very important for 2D modeling. At each time increment, the software computes a flow depth at each cell as well as each cell boundary, and assigns flow accordingly, resulting in a new computation at the subsequent time step therefore increasing the simulation time. Grid size is directly proportion to the computational time step. A time-step of 0.5 seconds was used for 7.5-foot grid cells.

### **4.2 Existing Condition**

The existing condition flood routing analysis was performed to identify existing street and surface conveyance, storm drain capacities, refine tributary drainage areas, and to acquire a benchmark for our proposed analyses. An actual historic storm event was used to correlate the hydrology and hydraulic model results to known flooded areas. Areas where recurring flooding persists during large storm events, were used as benchmarks for the existing conditions model. Coordination with the City was performed to ensure the model results correlated to actual witnessed events.

It should be noted that in this study, the focus was based on regional facilities and structures, not smaller local inlets and small laterals. Small pockets of flooding or localized ponding were not reviewed for draining unless near the alignment of a proposed regional drainage facility. Generally, the minimum size inlet to model is an 18-inch pipe or equivalent, unless it is associated with a known flooded area.

#### **4.2.1 Hydraulic Boundary Conditions**

The City of Encinitas is generally built on a bluff, above the receiving water bodies. As such, downstream water surface controls do not impact a majority of the City’s drainage conveyances, except for those areas adjacent to Cottonwood Creek. The Cottonwood Creek channel, and its tributary were not modeled as part of this study as it is a County/USACE facility. The creek itself and a majority of its drainage area is in the model but the portion of drainage area upstream of the City boundary was not added to the model.

The existing and proposed mainline storm drains that tie into the Cottonwood Creek will not be impacted by the hydraulic grade line within the channel/culvert system since the timing of the peak on the City facilities will occur well before the timing of the Cottonwood Creek maximum stage.

#### **4.2.2 Model Correlation**

Model calibration is ideally performed when a particular watershed contains both stream gages and rain gages. The stream must capture all runoff within the watershed without overtopping, free of detention or retention basins, and the watershed runoff must be completely contained, not allowing for bifurcation into adjacent watersheds. To be effective, the gage data would have to contain decades of record information. This is often not the case when dealing with urban watersheds, especially areas that contain large depressions that store and percolate flows rather than discharge into a receiving stream. The Encinitas area does have rain gage data, but none of the streams or main storm drain area equipped with flow gages, which is typical of urbanized drainage systems. The industry standard for correlating urban hydrology/hydraulic models is to use record documentations in the form of photos, videos, and field observation for a given storm event.

Using rain gage data, models can be developed, and calibrated if necessary, to mimic known flooded conditions at multiple locations within the watershed. This procedure is relatively new and is best used with 2-D based models. In this study, known storm event data in the form of time versus precipitation depth, was input into the XPStorm model and allowed to be distributed over the entire watershed topography. Loss rate calculations were performed based on the San Diego County Hydrology Manual using land use, soil, and roughness data of the watershed. The assumption that is made in this type of correlation model, is that the distribution of rainfall (hyetograph) is constant over the entire watershed. In reality, rainfall patterns vary as a storm moves through a watershed. This assumption is generally more suitable for winter storm patterns, rather than summer thunderstorms.

Although not a perfect calibration process, this method provides a correlation with an actual storm event and the associated flooding that historically occurred. The results are referenced with documentation and persons with firsthand observation to identify if the model is within an acceptable margin of error; generally, less than 10-percent maximum depth. If the model is showing a difference, the loss rates are adjusted until maximum flooded depths are acceptable.

Once the model has been correlated to the known maximum depths of a particular storm event, it is then evaluated for the maximum design storm event for the study. In this case, the 100-year/24-hour storm event.

Three historical storm events were evaluated to establish a correlation between the modeled results and actual documented flooded areas. The storm event with the most documentation was the December 12, 2014 event, and generally provided incremental precipitations that resembled the 24-hour duration design storm used in this study.

Figure 4-1 shows the results of one location, along Union Street and Vulcan Avenue that experienced severe flooding during the 2014 event. Estimated water surface elevations for the storm were approximated by the photo above using known landmarks and their corresponding elevations. The maximum depth at this location for this storm was estimated based on the photographs to be 1.5 to 2 feet within the street section. The modeled maximum elevation along the street was calculated at 2.0 feet.

Another location evaluated for the December 12, 2014 storm (Figure 4-2) shows the flooding that occurred within the parking lot along North Coast Highway of the now Le Papagayo restaurant. This photo was taken prior to the construction of the restaurant but the location was used for verification. From the photo, the location of the pond depth was estimated to be about 8-inch to 1-foot deep. The model results showed this location to be approximately 0.9 feet maximum depth.

The model was correlated to the December 12, 2014 storm event and was used to compare with the recent November 28, 2019 (Thanksgiving) storm event. Although this storm was a shorter (more intense) duration, it still provided reasonable results when compared to graphical evidence. Since the loss rates were originally correlated based on a longer duration storm event (December 2014), the modeled results showed slightly higher flooded depths in the model, which is consistent with what was expected. Figure 4-3 shows the location adjacent to Leucadia Park, along the alley known for extensive flooding. The

calculated depth of approximately 1.8 feet was calculated near the garage door with a maximum of about 3.3 feet in the center of the alley where the pump is shown in the image. The images provided by the City suggested approximately 1.5 feet at the garage door, and 2.5 feet depth at the pump location. This discrepancy could also be due to the pumping system the City used to help mitigate the flood damage.

Model results for the December 12, 2014 and the January 21, 2010 storm events are shown in Figures 4-4 and 4-5. The 2010 storm event produced a larger volume but lacked reliable comparative documentation.

Figure 4-4 shows the model results for the December 12, 2012 storm event after validation of the models for the L101 and Vulcan Subareas. The results of this validation was then used to model the January 21, 2010 storm event. Of interest in these models (similar to the 100-year Existing Condition model) was the bifurcation of the Vulcan watershed runoff into the L101 watershed. During the modeled storm, it was seen that flows ponding along Vulcan Avenue were splitting off and running west, through the railroad ballasts. The most extreme location occurred just south of the Leucadia Blvd. crossing at Vulcan Avenue, and just north of Jason Street along Vulcan Avenue.

Figure 4-1. Union St. 2014 validation Storm

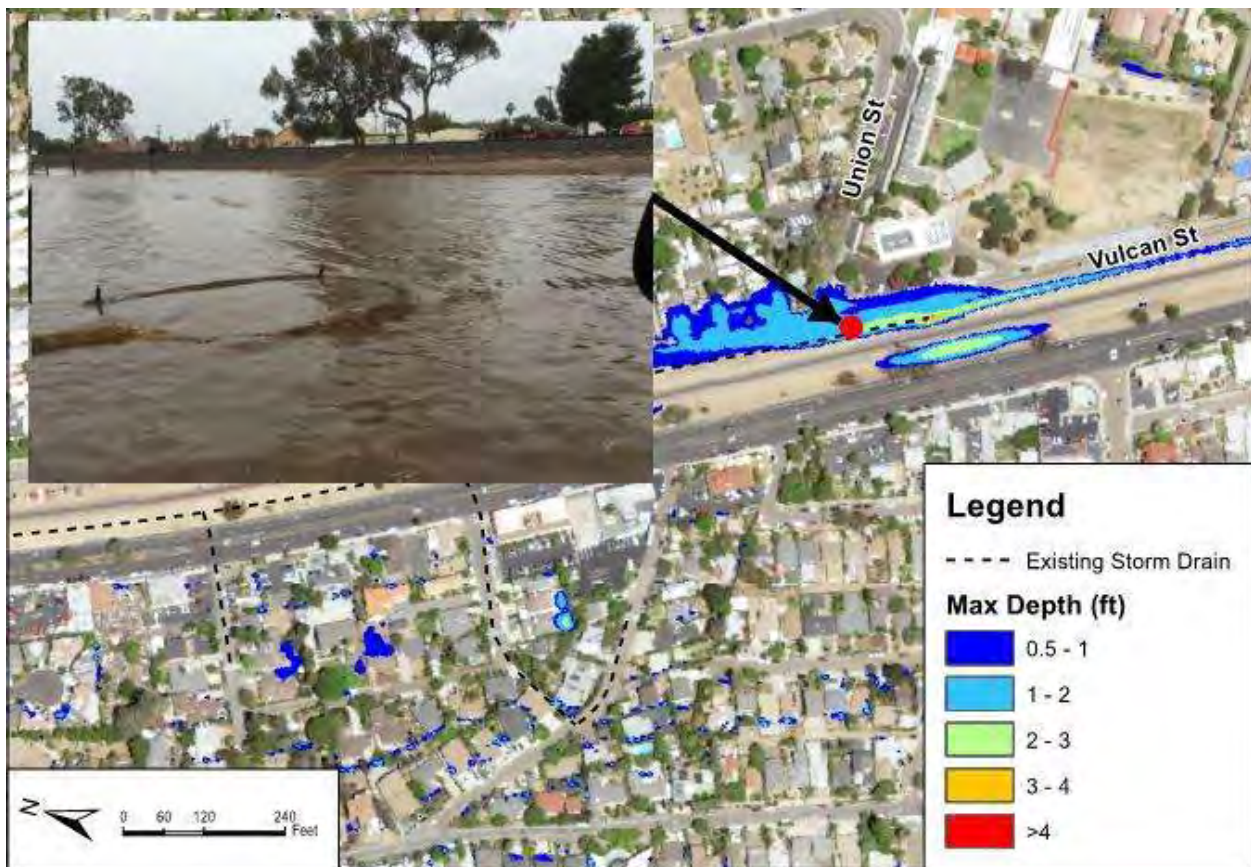


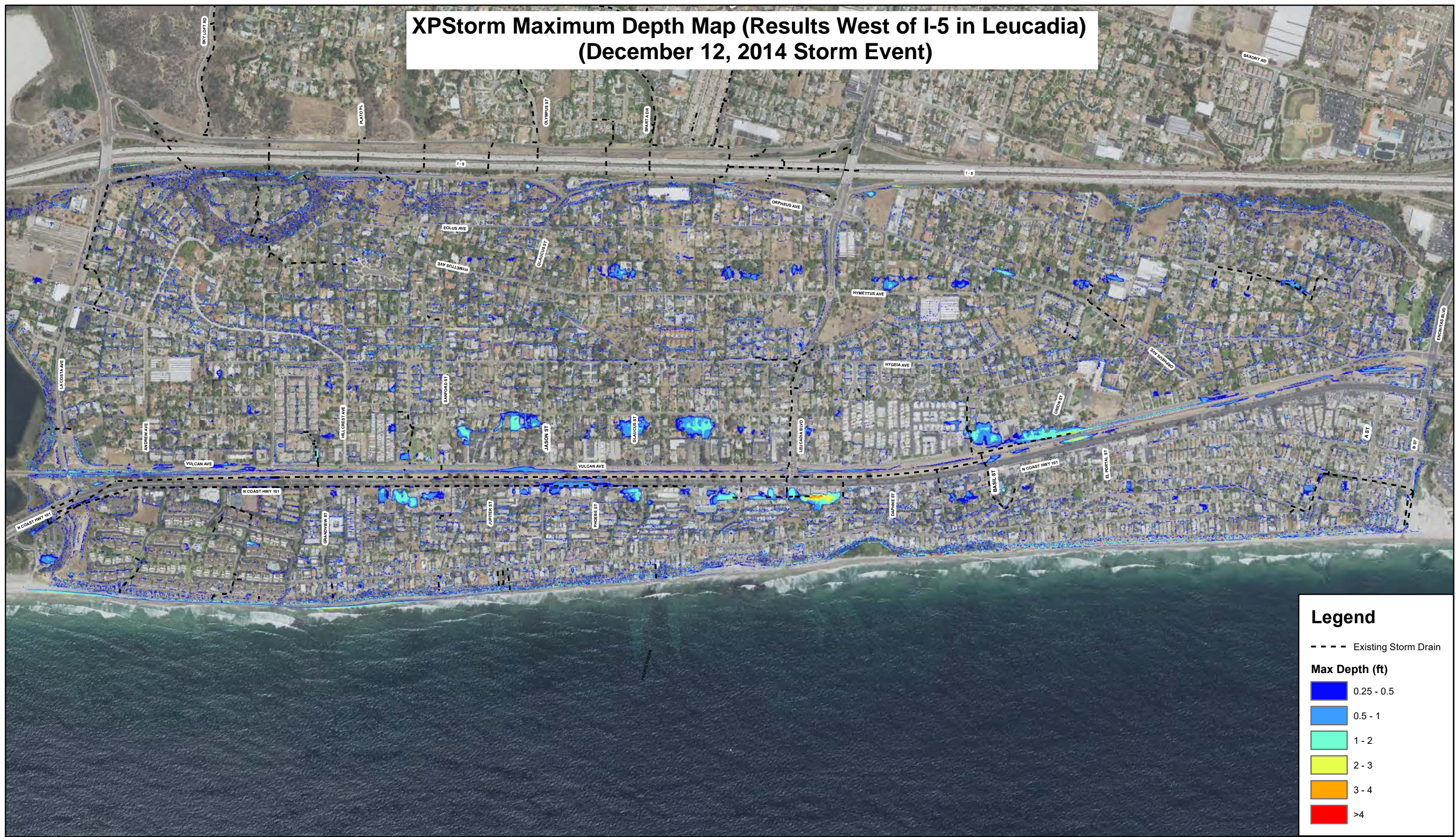
Figure 4-2. Parking lot 2014 Validation Storm



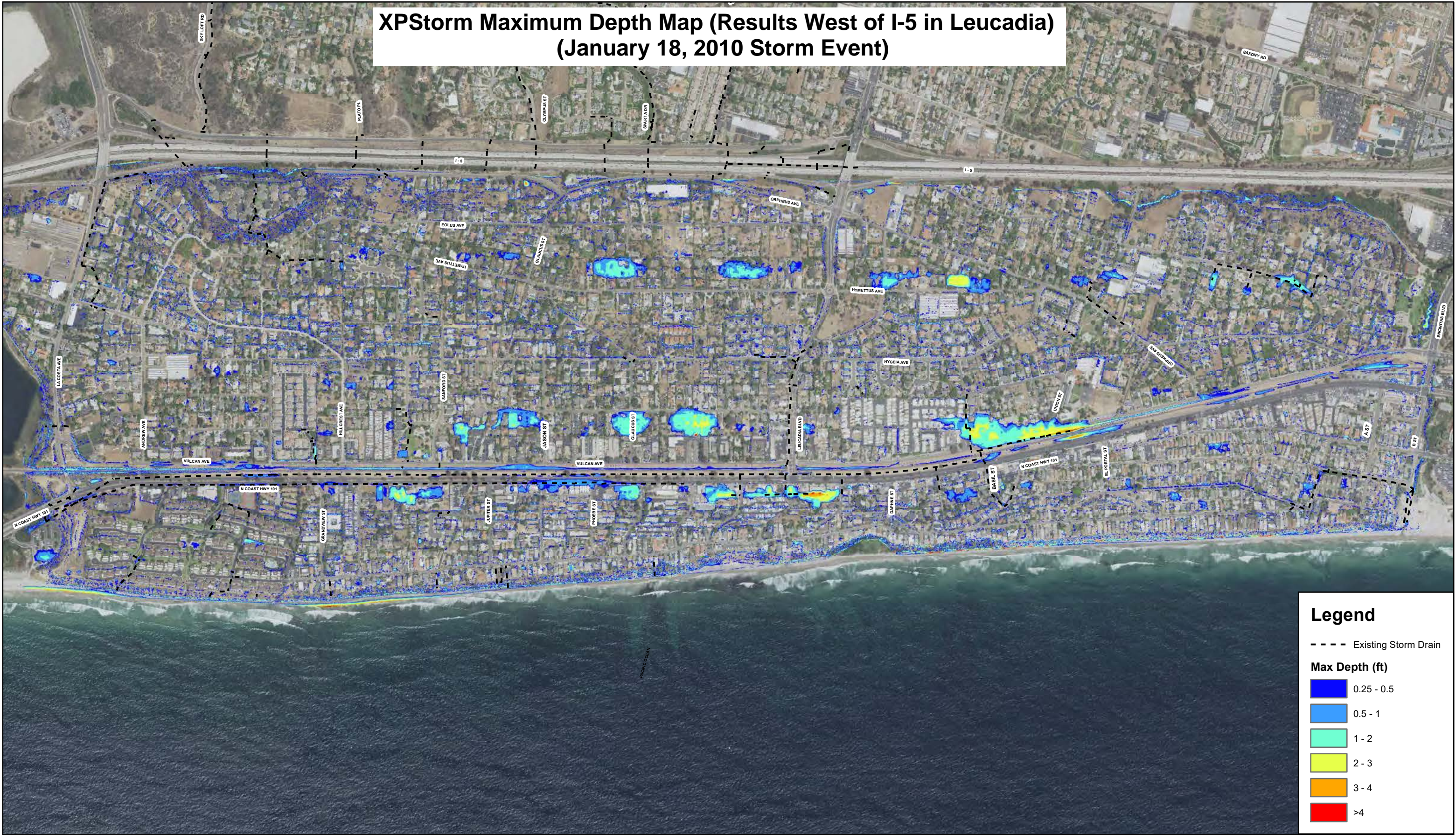
Figure 4-3. Leucadia Park 2019 Validation Storm



**XPStorm Maximum Depth Map (Results West of I-5 in Leucadia)  
(December 12, 2014 Storm Event)**



**XPStorm Maximum Depth Map (Results West of I-5 in Leucadia)  
(January 18, 2010 Storm Event)**



**Legend**

--- Existing Storm Drain

**Max Depth (ft)**

|            |            |
|------------|------------|
| Blue       | 0.25 - 0.5 |
| Light Blue | 0.5 - 1    |
| Cyan       | 1 - 2      |
| Yellow     | 2 - 3      |
| Orange     | 3 - 4      |
| Red        | >4         |

#### 4.2.3 Existing Condition Model Results

The baseline existing condition model was developed and run for the 100-year/24-hour, 50-year/24-hour, 10-year/24-hour, and 5-year/24-hour design storm events for each of the Watershed areas within Leucadia and Old Encinitas. The maximum water surface elevations for the event were plotted on an aerial of the focused study areas. This being a regional drainage analysis, small drainage infrastructure (12-inches in diameter or less) were not modeled in most cases. This includes private storm drain systems and area-type drains that are used in residential and some commercial areas. As a result, smaller pockets of flooding will show up on the results maps that may not be reality. In the proposed condition models, many of these flood pockets were drainage to ensure the proposed main lines could convey flows from future connections.

Additionally, buildings were purposely not “blocked” in the model from flooding, as flows can and do get into structures. In some cases, the LiDAR topographic data displays foundations at grade elevation instead of raised, as they are in most cases. This would show more of a representation of the natural terrain. As a result, some location may appear that structures are severely flooded when, in reality, the areas adjacent to the structures are flooded.

Graphical model results for maximum depth of each of the Leucadia West (L101, Vulcan and South Leucadia) watershed areas can be seen in Exhibits 3 through 6 for the multiple frequency existing condition model results for the 1-, 2-, 10-, and 20-percentile annual chance (of exceedance) storm events.

The maximum depth results graphics show the maximum depth at each location over the entire storm event. These maximums do not necessarily occur at the same time. A “snapshot” taken at one location’s maximum event would not necessarily show the maximum at another location within a given watershed. The model simulations run the entire storm event for 24 hours. As the flows propagate downstream, it is likely that a maximum depth at a major low point will occur later than a maximum depth upstream. These results do not account for the City’s mobile pump operations, as it is difficult to verify when and where each truck would be able to be during a given storm. As a result, the maximum flood depth will depict slightly higher results than if pump truck capacities were included.

*Note:* It should be noted that the existing condition models will display areas where topographic depressions exist as flooded which may or may not occur in reality. Since the models were created with the focus on drainage system 18-inches and larger, there may be areas of private drainage systems or smaller drainage systems that drain these areas. In some cases, private systems were not accessible to the team for verification as they were within private property. In other cases, some systems drainage to dry-wells, that were assumed to be saturate and not accepting additional flows. As a result, these areas in the existing conditions will show as flooded. In the proposed condition models, most of these areas were assigned a drainage system that would properly drain the area to a main storm drain system. This was done to ensure the main systems are large enough to accept these flows when a future connection is made (or when the local system is constructed). If this system is less than 18-inches, it is not identified in the proposed conditions.

##### *L101 Watershed Existing Condition 100-year/24-hour Results*

An existing condition analysis was performed for the L101 watershed even though at the time of this study, the City was in the process of developing plans for the L101 Streetscape project. Results from this study were used to help develop a proposed alternative, but the final alternative hydrology and hydraulics was performed by others.

The full model results from the existing condition analyses are shown on the following exhibits:

- Exhibit No. 3-6: Leucadia West – 1%, 2%, 10%, and 20% Annual Chance Storm
- Exhibit No. 7-10: Leucadia East - 1%, 2%, 10%, and 20% Annual Chance Storm
- Exhibits No. 11-14: Old Encinitas - 1%, 2%, 10%, and 20% Annual Chance Storm

For the Existing Condition model results, the areas were divided into three regions. The Leucadia West model included the L101, Vulcan, and South Leucadia subareas. The Leucadia East model included the

areas east of the I-5 freeway within Leucadia. The exhibits illustrate the maximum flood depth over the duration of the storm event. In other words, the maximum depth at any given time. These storm events are based on 24-hour duration storm.

### 4.3 Proposed Condition

The purpose of identifying the proposed alternatives is to provide a backbone storm drain alignment that is able to convey a majority of storm runoff for a given storm event efficiently. It is important to note that the goal of a regional drainage study is to focus on the majority of a watershed. In some cases, there may be locations that experience localized flooding that are located too far or at elevations not suitable for capture and conveyance to a main line system. The priority is to try and capture as many locations as possible, especially within areas that potentially pose a threat to life and property.

As noted previously, when sizing of the drainage facilities, it was necessary to capture small pockets of flooding adjacent to the proposed main storm drain lines to ensure the proposed storm drains are large enough to capture these locally flooded areas in the future. Although these minor systems are not shown on the proposed backbone drainage plan, they are considered in the conveyance capacity of the main lines. The minimum proposed pipe system for this study was 18-inch circular pipe. Some areas that required smaller pipes to deflood may not appear in the “proposed facilities” but can be addressed during future projects.

#### Flood Control Measures

Four types of flood control measures were evaluated in this study. A measure could be used on its own, or a solution could include all of these measures. The first type of flood control is the use of green infrastructure (GI). One of the goals of GI is to increase the amount of pervious area, to allow for partial flow containment and percolation, reducing the overall runoff potential for a given area. This idea of reducing runoff within the watershed, before it gets into the system, was evaluated. Since most of the City is currently “built-out”, many of the proposed GI locations would need to be retrofitted into the current land use. In areas such as Leucadia, multiple streets contain earthen shoulders, currently used for parking. Although these areas are currently pervious, they are not designed to contain or capture flow. After years of enduring vehicular traffic, the soil compaction greatly reduces their potential to infiltrate flows. This study evaluated the potential of converting these “shoulders” into planned pervious areas. This could mean reduction of parking within these areas, as vegetation would not be allowed to grow in areas where cars park often.



*Hymettus Ave Shoulder Parking*

Other types of GI include vegetated biotreatment, biofilters, and dry-well facilities. One issue with drywell facilities are their lack of percolation rate and propensity to clog over time. Even at high percolation rates (over 2-inch/hr), this rate is no match for large storm event runoff that will quickly overrun the system and cause flooding. Typically, these systems are used to provide some flood control during very small storm events, where flows can store within the laterals and system and percolate over time.

One type of facility not mentioned is regional flood attenuation/percolation. The purpose of attenuation is to capture and store runoff until the peak of the storm has subsided, then release the flows in a controlled manner. Retention facilities capture flows and percolate over a period of time (typically two to three days). Both surface and subsurface basins could provide benefit of reducing downstream facility sizes.

To be effective, these facilities require a lot of land, and in the case of the urbanized areas, could suggest land acquisitions. Subsurface storage is always a potential option but is extremely costly for regional drainage watersheds. Underground storage is typically used for small drainage areas.

The fourth type of flood control measure is the capture (surface inlets) and conveyance. This requires locating more efficient surface inlets to capture flows for storm drain conveyance. In many cases, adding additional inlets was necessary. Areas within Leucadia pose issues due to the lack of curb and gutter, which does not allow efficient surface drainage. Proposed inlets in this study, therefore, were mostly identified at low points within these areas.

Based on the capture of runoff within the respective watersheds, surface and subsurface drainage facilities were identified to convey the stormwater to one of three potential outfall areas. The goal for identifying the most feasible subsurface conveyance type and size depended on the location, known utility conflicts, and downstream outlet receiving water conditions.

The proposed drainage solutions in this study contain a combination of the afore mentioned methods of flood control measures and water quality treatment.

#### Water Quality Measures

Water quality concept measures were evaluated and proposed as part of this study. Locations for both GI and water quality treatment facilities have been proposed within the watersheds. It should be noted that this study provides a “planning level” guidance, and actual treatment facility design is performed during the individual project implementation and construction. More detailed evaluations of site and soil conditions are performed at that time and the type-selection and design of the water quality treatment facility should be based on the individual project and regional area goals. GI facilities provide water quality benefits by reducing effective runoff and treating contaminants within the runoff.

In addition to GI, some potential locations for storm water treatment have been identified within the watersheds along locations where new storm drain is proposed. In areas where no storm drain is proposed, other potential options for water quality treatment should be investigated

Coordination with the San Elijo Joint Powers Authority (SEJPA) was conducted to identify locations for potential nuisance flow diversion to the Cardiff treatment plan. SEJPA is currently working on a two-phased plan to increase the capacity of their current stormwater divert and treat operation. As part of this study, a location was selected to divert nuisance flow to a pump station that could be routed to the headworks of these new proposed SEJPA projects. This plan would help reduce nuisance flow pollution at Moonlight Beach.

The proposed infrastructure alternatives in this study were divided into two main drainage areas: 1) Leucadia Watershed; and 2) Old Encinitas Watershed.

## **4.4 Cost Estimates**

Cost estimates were created for each of the conceptual alternatives. The unit prices were developed in cooperation with the City and current market values. The calculated system cost estimates include costs for engineering, construction, environmental and permitting, construction management, traffic control, and contingencies. Any new storm drain construction within the City will most likely require utility relocation. This can be very costly especially considering the area is highly urbanized. The quantity and complexity of utility relocation is unknown and requires detailed site-specific subsurface investigations.

Pipe costs are per linear foot and include costs for excavation, shoring, bedding, backfill, compaction, removal of excess material, and trench resurfacing. Unit prices varied based on the depth of the facility. In some cases, depths reached over 30 feet. For these projects, additional costs were added to the installation of the pipe.

Green infrastructure (or vegetated buffer areas and biotreatment and porous paver) prices were based on the recent L101 project bid lists. Structural water quality treatment facilities were estimated based on size and similar type constructed projects.

Due to the fact that construction will take place over a number of years, the total costs of drainage improvements will vary from the numbers provided in this study. It is recommended that any future

implementation plans take into account future construction unit costs prior to creating a funding program for the proposed improvements. The California Construction Cost Index is **8080** as of October 2021.

## 5 WATER QUALITY

The City of Encinitas resides in the San Diego Region of the California Regional Water Quality Control Board (RWQCB) and is a co-permittee of the National Pollutant Discharge Elimination System (NPDES) Permit and waste discharge requirements for discharges from the municipal separate storm sewer systems (MS4s) for watershed drainage (Order Number R9-2013-0001, amended by orders R9-2015-0001 and R9-2015-0100).

This permit (MS4 Permit) identifies water quality guidelines for stormwater and non-stormwater waste discharges into waters of the U.S., which in the case of this study includes the Batiquitos Lagoon and the ocean. The evaluation in this study focuses primarily on stormwater runoff guidelines and recommendations for new development and re-development.

For stormwater quality guidance, the City also developed a Stormwater Standards Manual (Manual) to establish minimum stormwater management requirements and controls. Although the Manual focuses on requirements for source control (existing development), construction activities, and post-construction, this study primarily focuses on existing conditions (retrofit) and post-construction measures.

Encinitas is part of the Carlsbad Watershed Management Area. Water quality priorities are developed based on potential impacts MS4 discharges may have on receiving water bodies and the level priority a particular water body is designated, as discussed in the MS4 Permit.

### **Water Quality Storm**

“First flush” is a term used to identify the most polluted runoff from a given storm event. The industry standard, and what is identified in the NPDES MS4 Permit is considered to be the runoff produced from a 24-hour, 85<sup>th</sup> percentile storm event. In other words, for a given precipitation depth, 85 percent of all 24-hour storms would fall within that given depth (or less) over any given year. This has been identified as the storm most detrimental to water quality, as it has the potential to wash most of the pollutants from the surface into the storm drains. The degree of contamination due to storm runoff reduces significantly for precipitation depths beyond the first flush.

As part of this study, opportunities for water quality treatment were evaluated using different types of structural best management practices. As it pertains to regional drainage studies, locations for green infrastructure were evaluated within the watersheds in addition to locations for regional water quality treatment where space was available. It should be noted that the evaluation within this study is conceptual, and a full evaluation of water quality treatment potential should be performed on a project-by-project basis at the time of implementation. The methods and facilities identified in this study are recommendations only and it is expected that further evaluations and more detailed investigations will be completed during the final design phases of projects.

### **5.1 Green Infrastructure**

Green infrastructure (GI) includes the use of more natural facilities to reduce the impacts of urbanization as it pertains to stormwater management. GI can provide benefits within a watershed by minimizing runoff from directly connected impervious areas, increasing percolation and groundwater recharge, treatment of runoff, and create biodiversity. GI is most beneficial when implemented as part of a project’s initial planning process but could also be constructed after projects have been constructed.

Most of Leucadia and Old Encinitas was constructed prior to GI concept development. Proposed GI improvements for the entire watershed are difficult given the lack of undeveloped area remaining in the two watersheds. Redevelopment projects, including future street improvements (streetscape) provide a good opportunity to implement GI into the current land use. A cursory evaluation of potential locations for implementing GI has been performed in the area of Leucadia in this study. This evaluation is a “first cut” estimation of potential locations, but further site-by-site evaluations are necessary prior to final

design. Refer to Appendix C for estimated potential locations for GI in the Leucadia watersheds. The Leucadia watershed (specifically the L101, Vulcan, and South sub-watersheds) were the focus due to the areas' extensive flooding issues.

This study focuses on GI as it pertains to flood control and potentially water quality treatment. Some examples of typical GI elements are included below.

**Bioretention:** Bioretention is a process of filtration and percolation that removes pollutants through physical, biological, and chemical treatment processes. Bioretention can reduce urban area runoff volume for smaller storm events. These types of facilities can be designed to percolate captured flows, or detain flows and release them slowly over a period of time. Another benefit to using biofiltration can be to add a landscaped area within an urbanized plan.



*Street side median biofilter (Brad Landcaster)*

Potential issues for these systems include vegetation establishment and maintenance, maintaining percolation rates, and available space. In semi-arid regions, irrigation may be necessary. For areas containing soils that cannot percolate effectively, under drain systems need to be installed and maintained. Underdrain systems also require available head to operate and to drain to a downstream system.

As a volume-based treatment facility, these types of BMPs can only attenuate small volumes of runoff making them best suited for local, not regional treatment.

**Vegetated Buffer Areas:** Similar to bioretention, vegetated buffer areas provide biofiltration. These buffer areas can be in the form of bio-swales or bio-strips. The vegetation has a filter, or screen, effect on flows passing through. This effectively reduces velocities and promotes sediment and gross solid capture within the vegetation. Root uptake of pollutants is a benefit but is not considered a major source of reduction. These facilities are used to “buffer” the impact of urbanization by disconnecting the impervious areas within a drainage area.



*Vegetated Buffer Strip (CASQA)*

Potential issues for these systems also include vegetation establishment and maintenance. In semi-arid regions, irrigation may be necessary. Typically found along roadways, these facilities cannot incur vehicular traffic. This may be a problem in areas around Leucadia where residents currently park along street shoulders.

**Stormwater Runoff Harvesting:** Stormwater harvesting is the process of re-using captured and treated rainfall runoff. Beneficial uses for harvesting can include irrigation and percolation into ground water (similar to bioretention). These types of facilities typically are used for small application such as rooftop collections systems but can be used for roadway runoff and more regional systems as well. For larger systems, these-system can become more expensive as the infrastructure to provide treatment, circulation (pumping), storage and distribution are generally required. Even for smaller systems, other than groundwater recharge through infiltration, maintenance of storage and distribution systems can require extensive maintenance.

Harvesting for regional systems can be done but only for very low flow events. In cases of major stream systems, dry weather flow can be used for harvesting. In most cases, only a portion of the dry-weather flow can be used for harvesting if pumping is required.

**Porous Pavers and Pavement:** Porous pavement or pavers is engineered hardscaped surface that allows runoff to percolated through it. Beneath the pavement is a layer of permeable media such as an aggregate base with a relatively large void space ratio to allow for flow to move and or be stored. Stored runoff can either be infiltrated or removed via a smaller subsurface drainage system to be connected to a storm drain system downstream.



*Porous Pavers*

Porous pavers provide a good alternative to standard (impermeable) pavement. Locations for porous pavement/pavers can be along residential streets to provide parking, within parking lots, or even residential and commercial driveways.

Porous pavement is a specially engineered material (such as porous asphalt) that allows runoff to flow through it. The material is generally more coarse than typical asphalt and can costs 20- to 30-percent more to install. A potential issue with porous pavement is clogging of the pores due to sediment (wind blow or transported by runoff). If possible, pretreatment of sediment laden flows should be performed to increase the lifespan of the pavement's porosity.

Pavers provide a durable surface material that can also be vegetated. Vegetation may require irrigation but can provide an additional water quality benefit due to the root uptake of runoff constituents. Potential issues with pavers include compaction of sub-base material over time, which will greatly reduce the system's ability to percolate. If vegetation is desired to be used, improper irrigation could fill the sub-base reducing the system's ability to percolate or store stormwater runoff.

## 5.2 Structural BMPs

Structural water quality treatment facilities can be constructed to treat runoff from regional and local drainage areas. Several types of structural BMPs exist and vary depending on the desired treatment mechanism. Any system proposed within the City should adhere to the guidelines identified in the City of Encinitas BMP Design Manual.

As discussed previously, a majority of the study watersheds are built-out, leaving not much opportunity for regional treatment. As will be seen in Section 6, many of the main storm drain facilities are well below the surface, creating issues with diverting flows to available undeveloped areas along the proposed alignments for surface treatment. Subsurface storage/treatment can be implemented and will be evaluated for feasibility along the proposed drainage facility alignments.

Structural BMPs can either be designed as in-line or off-line structures. In-line structures are designed so that the main storm drain runs directly through the BMP. Flow-by facilities are designed off-line and collect runoff from a diversion structure within the main storm drain line. The benefit of flow-by structures is, they do not typically affect the hydraulic capacity of the main storm drain facility. In-line structures can cause extensive hydraulic losses within a storm drain facility if improperly maintained.

## 5.3 Dry Weather Flow Diversion

Dry weather flow, or nuisance flow is the daily runoff from urban areas generated by mostly unnatural sources. Un-natural sources include over irrigation and washing of cars, where natural flows can be

exfiltration from groundwater. Dry weather flows in larger watersheds can occur year-round. In summer, typical levels of flow can be less than in winter months.

These flows can contribute to the pollution of downstream receiving waters, as the flows occur all the time, not just during storm events. Typical pollutants can vary depending on watershed and type of stormwater conveyance facility. Although dry weather flows typically do not exhibit high velocities, sediment is not of much concern. Some of the pollutants of concern include bacteria, detergents, turbidity, nitrogen and phosphorus. Levels of dissolved oxygen and total organic carbon can be affected with slow moving or stagnant dry weather flow.

Moonlight Beach is one of the major stormwater outfalls for not only Leucadia but the Old Encinitas area as well. Cottonwood Creek discharges to Moonlight Beach and has a history of bacteria issues.

*Enterococcus* is considered a fecal indicator bacteria and has been found in samples near the outlet of Cottonwood Creek at Moonlight Beach. A study performed in 2012, “San Diego County Enterococcus Regrowth Study” by Southern California Coastal Water Research Project (SCCWRP) researched the source of *Enterococcus*. The results concluded the sources were primarily naturally forming. Currently, an on-site Ultra-Violet (UV) treatment facility treats nearly 85-percent of the annual dry weather flow within Cottonwood Creek, yet according to the study, measurement taken downstream of the facility were still high in *Enterococcus*. The findings suggested that the bacteria was reintroduced into the creek within the ponded areas as a result of decaying organic matter, freshwater plants and algae, seaweed, and bird droppings near the outlet.

In light of this, it is recommended in this study to not discharge more stormwater into Cottonwood Creek, but rather directly to Moonlight Beach. These dry weather flows should be treated for bacteria prior to discharge. Adding additional dry weather flow to Cottonwood Creek would potentially increase the dry weather flow within the creek, resulting increased potential for bacterial growth downstream of the current UV treatment facility.

#### **San Elijo Joint Powers Authority (SEJPA) Stormwater Capture and Reuse Project**

SEJPA is currently planning for the development of a two-phased project designed to capture and reuse stormwater runoff at their San Elijo Water Reclamation Facility in the City of Encinitas. Current planning includes expanding operations to provide capacity to increase treatment of dry-weather stormwater runoff. This project will divert stormwater from a regional storm channel and redirect flow into a new groundwater infiltration basin where it will be extracted for advanced treatment and distribution as recycled water. The goal of this project is to provide water quality treatment and provide additional water supply.

This facility, known as Stormwater Capture and Use Phase 2 Project (Phase 2 Project) will build on previous investments (Phase 1). Currently, the San Elijo Water Reclamation Facility diverts and treats dry weather runoff (in the range of 400 gpm) from a drainage tributary to San Elijo Lagoon. Phase 2 will expand on this operation to increase the available capacity for treatment and distribution.

As part of this study, coordination with the San Elijo Joint Powers Authority (SEJPA) was conducted to identify locations for potential nuisance flow diversion to the Cardiff treatment plan. In coordination with SEJPA and the City, a location was selected in the South Leucadia subarea to divert nuisance flow to a pump station that could be routed to the headworks of the proposed SEJPA project. This plan would help reduce nuisance flow pollution at Moonlight Beach.

## 6 DRAINAGE AREA RESULTS

### 6.1 L101 Area Alternative (Future Improvement)

At the time of this study, the L101 Streetscape project was on-going. Q3 developed a preliminary model to identify a regional drainage solution for the area west of the NCTD railroad tracks (L101 Subarea). This model and proposed system was used as the basis for the future Final Design for the proposed drainage infrastructure as a part of the ultimate L101 project. As a result, the models prepared as part of this study were further developed to accommodate the final design plans for the streetscape projects. Although obsolete, below an overview of the original model assumptions are discussed.

The L101 alternative is one of three proposed regional drainage improvements that make up the West Leucadia Subarea drainage plan. The proposed alternative utilizes the existing infrastructure and proposes a larger facility to accommodate larger storm runoff. Together the three regional systems (L101, Vulcan, and South storm drainage systems) provide a single 100-year (1% annual chance exceedance) flood control solution for the West Leucadia Subarea.

Another option that was considered for these areas was a single regional system that treated 90-percent of the West Leucadia Subarea. This system would contain multiple laterals that would connect the systems, primarily running under the NCTD railroad right-of-way. A single larger system could ultimately cost less, but the cost for the single project would be too significant for the City to implement at one time. By developing this three-facility system, the project can be phased to provide more manageable project costs. With the construction of L101 Streetscape, the City had the opportunity to develop one of the three systems.

#### **Proposed Flood Control Facility**

The L101 regional drainage system is currently in Final Design by others. At the time of this study, the project was being implemented in multiple phases with the construction of the south section of the L101 (Phase 1) followed by the construction of the North end of the L101 project (Phase 2). The initial proposed alternative included keeping the existing 24-inch storm drainpipe that currently drains low flows from most of the L101 and portions of the Vulcan Avenue area. This drain would remain in ground but would only be used to de-flood the Union Street/Vulcan Avenue area, known for excessive ponding. This system would be separated from its current connections to drainage infrastructure along the L101 to ensure no surcharging could occur along the alignment as flows move north.

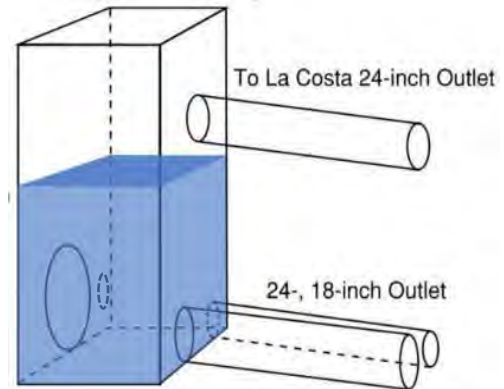
Historically, this system would back up (surcharge) causing excessive flooding at several locations. Manual sluice gate control was required during a storm event to minimize surcharging along L101 while de-flooding the Union Street/Vulcan area. By removing the existing sluice gate and isolating the system from any connections along L101, this system could more rapidly de-flood the Vulcan/Union Street area. Although the pipe is too small to eliminate flooding during large storms, it still can be used to help drain the area.

The preliminary regional system located in L101 as part of the study included storm drain pipe ranging from 24-inch to 60-inch diameter. The system begins near Basil Street and ends near La Costa Avenue. In addition, several laterals were proposed near Leucadia Park, Basil and Cadmus Street to improve drainage conditions.

Both the existing 24-inch low flow storm drain and the new proposed storm drain would confluence in a junction box located a few hundred feet south of La Costa Avenue along North Coast Highway. This junction box would be approximately 20-feet deep and contains a three-pipe, variable level, outlet. An 18-inch and a 24-inch pipe divert flows to the existing outlet located on the west side of N. Coast Hwy. into the Ponto Beach basins. Within the junction structure, several feet higher, an additional 24-inch pipe would discharge flows to the existing outfall located along the east side of N. Coast Hwy, just north of La Costa Avenue into Batiquitos Lagoon.

It is recommended in this study to utilize the existing 24-inch outfall that is currently in use by tying into the existing (newly constructed) local drainage system. The graphic below shows a schematic of the proposed junction structure and how it would function (interim solution). Small storm events would flow out the two lower pipes (to Ponto Beach basins), where larger storm events would trigger the upper 24-inch pipe discharging into Batiquitos Lagoon.

This configuration at the outfall provides a reduced flood control level of protection. It has been estimated that this system provides roughly a 20- to 25-year (24-hour) storm protection by itself for the L101 area. The ultimate condition proposed improvement includes constructing a separate system along Vulcan Avenue and one in South Leucadia. Once the Vulcan Storm Drain system and the South Leucadia Storm Drain system have been constructed, then this system would provide 100-year (24-hour) storm protection.



*Interim Downstream Junction Structure*

Similar to all the subarea models, the main focus is to eliminate the major flooded areas. Model results do show small pockets of flooding within the adjacent areas of the main proposed drainage lines. For a regional drainage study, this is typical. The goal is to propose a storm drain large enough to accept future (smaller) storm drain connections from these localized areas. For final model results, refer to the final design documents of the L101 Streetscape project.

### **Water Quality Facilities**

As part of the initial concept design phase for the L101 Streetscape project, a water quality study was performed to identify how much flow would be discharged into both outfall locations during a water quality storm event. As defined by the Regional Water Quality Control Board, a model was developed to evaluate the 85-percentile/24-hour storm event (“first flush”). Results of this study showed that only the two lower pipes were active during this event, and no flows were discharged to the Batiquitos Lagoon. For more information regarding this study, refer to the L101 Streetscape project reports.

Green infrastructure is proposed along the L101 Streetscape project. Preliminary proposed condition models run for this area included the grading plan of the 70-percent plans. Subject to change in the final design, the goal was to mimic the current infiltration characteristics, but not exceed, due to the recommendations provided in a prepared by Dudek, “Encinitas and Leucadia Watersheds Preliminary Stormwater Infiltration Hazard Zones”, November 15, 2019. This study was prepared after the recent bluff failure along the Leucadia coastline. The study suggested that increasing surface-to-groundwater infiltration could increase the stability of the bluffs. Consequently, not increases in infiltration were recommended as part of this study.

At the outfall, the low flow was purposely diverted to the Ponto Beach basins, and not Bataquitos Lagoon directly. The Ponto Beach basins include two inline vegetated basins and a 900 linear foot vegetated swale/basin before discharging into the channel that connects the Batiquitos Lagoon to the ocean. This system of basins provides a valuable water quality treatment mechanism prior to discharge into the channel. Figure 6-1 shows the Ponto basins configuration. During final design, this system of basins and swale should be refined to ensure target pollutant removal is maximized and peak flows are contained within the facilities.

With the proposed GI facilities, a goal of the City was to match the impervious area to that of existing conditions. At the time of this study, preliminary model results showed that this was the case, that no more volume was discharged for a given storm event. By developing better drainage infrastructure to route storm

runoff, it is expected that peak discharges would slightly increase, as the watershed lag is reduced due to more efficient conveyance, but the overall volume is relatively the same. The ultimate L101 storm drain will convey runoff, but also serve as a linear subsurface detention facility. The transition at the end from a 60-inch RCP to the three (3) smaller outlets restricts flows, utilizing the available volume within the storm drain system upstream.

Figure 6-1. Ponto Basins Configuration



Sediment has historically been an issue with Batiquitos Lagoon. Sedimentation is a process perpetuated by erosion within a watershed being washed out to the receiving water. Sediment loads can also come from scour within natural streams upstream of the outfall. In the case of L101, no natural water courses are present, and no foreseen erosion within the watershed is expected. Minor sediment would most likely be captured within the GI facilities. In the existing conditions, large non-paved areas and open space exist near inlets for the existing 24-inch storm drain that could have provided a source of sediment. It is anticipated that the post project conditions will actually reduce sediment discharge into the Ponto Beach basins and Batiquitos Lagoon. Since the overall land use of the proposed Streetscape project does not change compared to the existing condition, it is not expected that additional pollutants will be produced within the watershed.

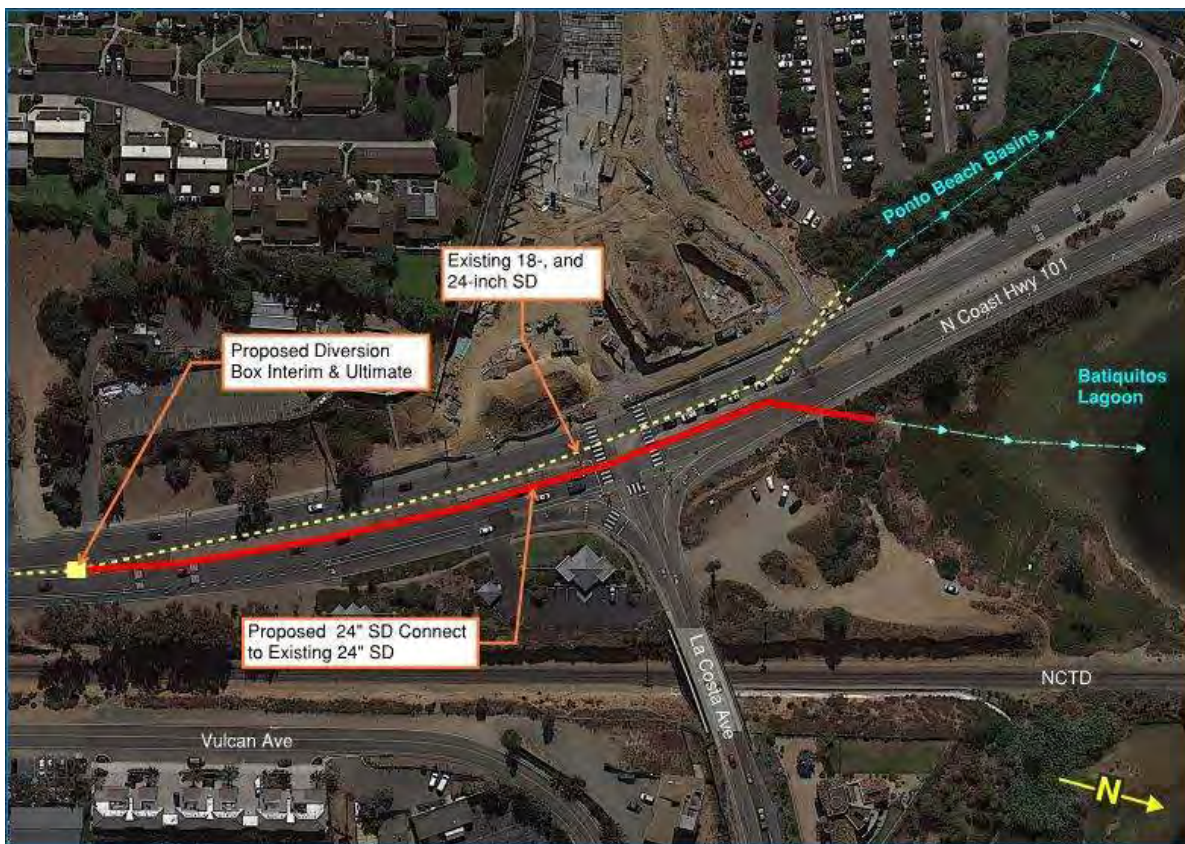
Although the volume of discharge to the Ponto Beach basin and Batiquitos Lagoon is not expected to change due to the implementation of the L101 project, the peak discharge will be higher, but for a shorter duration. The same volume of runoff will reach the outfalls faster than existing conditions. This typically would indicate that sediment and/or potential pollutants could increase in the overall discharge, as higher velocities

can carry silts and fine sediment further down the storm drain lines. To help mitigate this, the City proposes to use vegetated buffer areas tributary to the inlets. These vegetated buffer strips and biofiltration devices can reduce pollutant loads that could potentially get into the storm drain. In the existing condition, no such facilities exist and the large open earthen areas are allowed to pond, silt and discharge into the storm drain system.

The future proposed discharge pipe into the Batiquitos Lagoon will require an Environmental Impact Assessment. Historically, discharging stormwater into the Lagoon has been a point of contention. As a result, the environmental permitting for this project should be considered early in the planning process prior to final design.

Figure 6-2 shows the current Phase 2 proposed outlet configuration provides approximately 20- to 30-year storm protection for the L101 subarea. Once the improvements along Vulcan Avenue and South Leucadia are in place, this system will provide 100-year protection.

Figure 6-2. L101 Ultimate Outlet Configuration



### **Cost Estimate**

The cost estimate for this alternative is being developed by the City and their consultant as part of an on-going final design package as part of the L101 Streetscape project. A more detailed engineer's estimate will be provided per the final design of that project.

## **6.2 Vulcan Subarea (Future Improvement)**

Vulcan Avenue resides in a flat valley within the drainage subarea. Drainage within the watershed is generally routed towards Vulcan Avenue where it currently ponds along the street and along the east side of the NCTD railroad tracks. Areas between Vulcan Avenue and the I-5 Freeway contain several low points or sumps with no connection to a storm drain facility. At some of these locations, the City has

implemented dry-wells, which collect flows and percolate runoff over time. Although not considered a regional solution, these facilities have provided flood control benefits for smaller storm events.

The Vulcan subarea is a portion of the Leucadia hydrologic region identified previously. It is one of three Leucadia subareas that experience the worst flooding conditions. The Vulcan, South, and L101 subareas are interconnected, resulting in flow bifurcations during large storm events. To completely solve the regional Leucadia flooding issues will require implementing a drainage solution for all three subareas. The storm runoff conveyed by the Vulcan subarea are responsible for the most flooding within Leucadia.

Multiple regional alternatives were evaluated with respect to backbone drainage alignments and type of system. Both grey (typical drainage infrastructure) and green infrastructure alternatives were considered and evaluated. Green infrastructure (by itself) does not provide flood control protection for moderate to large storm events (i.e. greater than 10-year/24-hr) but was found to provide some benefit for reducing runoff for smaller storm events (i.e. 1- to 2-year/24hr). The proposed alternative selected consists of a mixture of both green and grey infrastructure.

### **Proposed Flood Control Facility**

Figure 6-3 shows the configuration of the proposed grey infrastructure improvements. These improvements were evaluated and sized based on the implementation of green infrastructure at location identified based on available space. A concept level drawing of the main line backbone for the Vulcan storm drain has been prepared in Exhibit 1.

The proposed backbone starts just south of the Union Street/Vulcan Avenue intersection and conveys flows north to the Batiquitos Lagoon. The proposed storm drain sizes range from 18-inch RCP to 72-inch. The outlet pipe was restricted to 48-inch RCP to induce storage within the pipe and reduce peak flow out of the proposed system. This section of Vulcan is extremely flat resulting in proposed storm drain slopes of 0.7- to 0.2-percent. The depth of the system will require special trenching techniques to construct to minimize impacts to traffic and neighboring residents. Depth for this facility will range from a couple of feet to over 20 feet along the alignment of the backbone facility.

Secondary storm drain laterals tributary to the Vulcan backbone alternative includes three systems: Lateral V-1 (Hymettus Avenue & Leucadia Boulevard); V-2 (Hymettus Avenue & Glauca Street); and V-3 (Jason Street). These laterals de-flood areas that currently contain uncontrolled runoff within the subarea.

Lateral V-1: This lateral extends from Orpheus Avenue (at the flooded location known as Orpheus Lake), to Hymettus Avenue, down Fulvia Street to Leucadia Blvd. This system joins the Vulcan storm drain at the intersection of Leucadia Blvd. and Vulcan Avenue. This lateral was sized based on required capacity to drain the areas within this portion of the sub-watershed. Future investigations could be performed to identify if a parallel system could be used in conjunction with the existing Leucadia Avenue storm drain. A total of 9 inlets will need to be modified and/or installed to drain all the areas of known flooding.

Lateral V-2: This lateral begins at Hymettus Avenue and Naiad Street and extends north approximately 1,000 linear feet where it traverses west through private property. An alternate alignment could be to extend the Hymettus Avenue storm drain further north to Glauca street but would have to buck grade for approximately 650 feet adding an additional 10 feet of covert to the proposed system. The system extends to East Glauca Street, west across Hygeia Avenue until it discharges into the Vulcan storm drain at the Glauca/Vulcan intersection. This Glauca storm drain also intercepts a proposed lateral along Hermes Avenue. A total of at least 8 catch basin inlets would have to be modified or installed along this lateral.

Lateral V-3: This lateral drains a portion of Hermes Avenue and extends from Jason Street north approximately 330 feet. From the Jason Street/ Hermes Ave. intersection, the storm drain continues west

along Jason Street and terminates into the proposed Vulcan storm drain. A total of 4 modified or new catch basin inlets are proposed along this lateral.

Figures 6-4 through 6-6 show the proposed secondary storm drain systems or laterals tributary to the Vulcan storm drain line. Although these laterals provide local drainage solutions for the localized flooded areas, the alignments can, and should, be re-evaluated during final design. The goal of this study is to provide a basis for future design and is not to be considered final in alignment or size.

A more detailed Concept Design Plan was prepared for the Vulcan Main storm drain line. This line can be seen in Exhibit 1. The concept plan is a 30-percent plan of the proposed storm drain and provides a basis for future final design. These plans provide a refined alignment and identifies potential utility conflicts such as right-of-way and major utilities. Further refinement of utility location must be performed during final design.

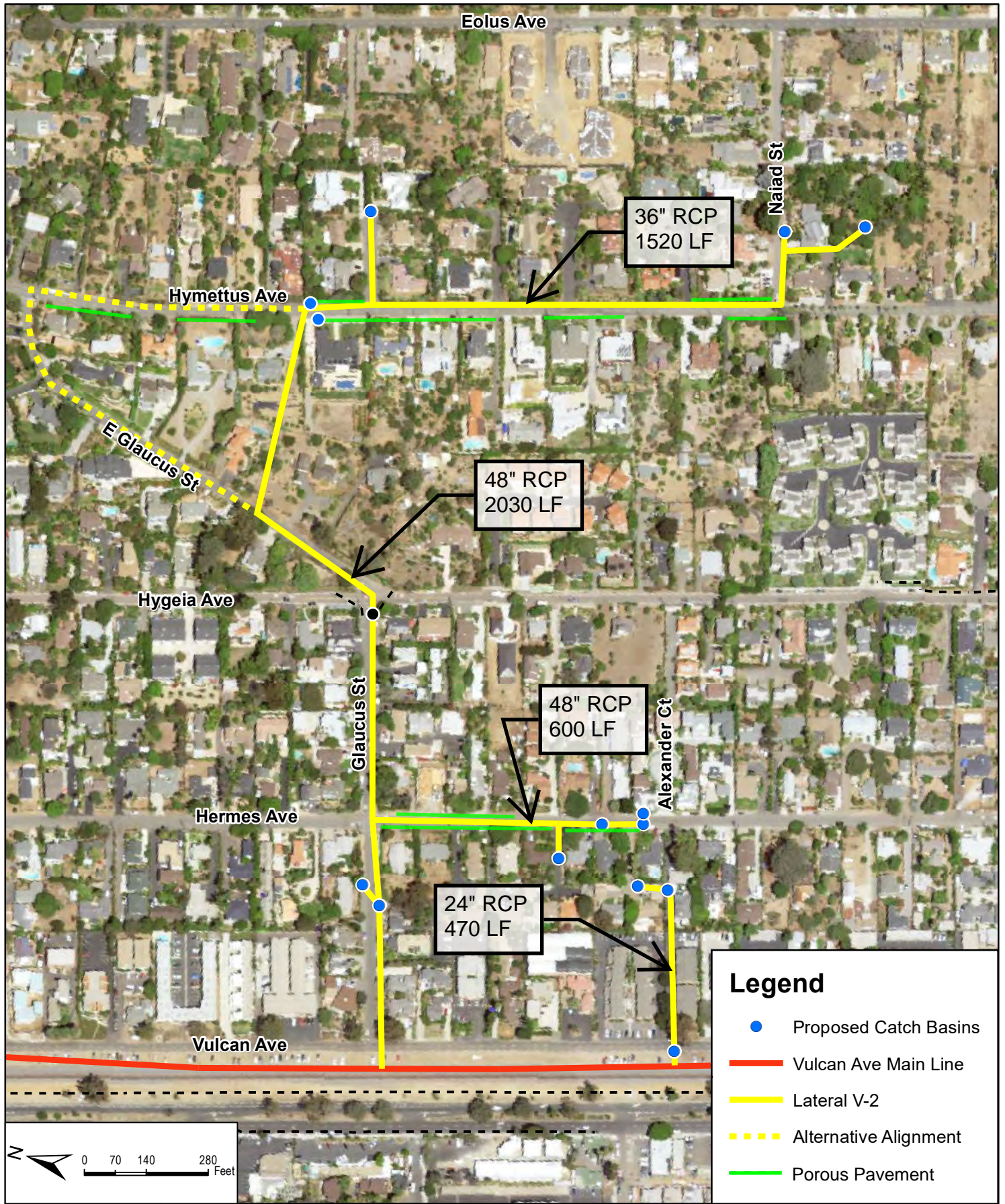


Drainage Feasibility Study

## Vulcan Subarea Proposed Facilities Layout

Figure 6-3







### **Water Quality Facilities**

Green infrastructure in the form of vegetated buffer strips and/or biofiltration is conceptually proposed along the Vulcan storm drain proposed alignment and within the watershed at locations currently not developed or paved. Subject to change in the final design, the goal was to mimic the current infiltration characteristics, but not exceed, due to the recommendations provided in a prepared by Dudek, “Encinitas and Leucadia Watersheds Preliminary Stormwater Infiltration Hazard Zones”, November 15, 2019.

With the proposed GI facilities, a goal of the City was to match the impervious area to that of existing conditions. Preliminary model results showed that this was the case, that no more volume was discharged for a given storm event. By developing better infrastructure to route storm runoff, it is expected that large storm peak discharges would increase, as you are getting the flows out quicker, but the overall volume is relatively the same.

At the outfall, a water quality treatment facility is conceptually proposed to be located just south of La Costa Avenue, near the system outfall. This completes a water quality “treatment train” consisting of vegetated buffer strips, biofiltration, and water quality treatment facility and will provide treatment to the runoff captured within the Vulcan subarea watershed.

Currently, tributary flows are routed via the surface to Vulcan Avenue and migrate north through the earthen shoulder and temporary channel system adjacent to the NCTD railroad tracks. These concentrated flows have scoured the adjacent embankment, allowing sediment to be transported to the outlet. Sediment laden flows currently discharge into Batiquitos Lagoon just east of the railroad tracks, north of La Costa Avenue.

Sedimentation has historically been an issue within the Batiquitos Lagoon. Sedimentation is a process perpetuated by erosion within a watershed where sediment is transported from the drainage area to the receiving water. Sediment can also come from scour within natural streams upstream of the outfall. In the case of the Vulcan subarea, the earthen drainage facilities will be controlled, and no anticipated erosion within the watershed is expected. Minor sediment would most likely be captured within the GI facilities. It is anticipated that the post project conditions will reduce sediment discharge into the Batiquitos Lagoon.

Although the volume of discharge to Batiquitos Lagoon is not expected to change much due to the implementation of drainage infrastructure, the peak discharge will be greater. The runoff will reach the outfalls faster than existing conditions. This typically would indicate that sediment and/or potential pollutants could increase in the overall discharge, as higher velocities can carry sediment further down the storm drain lines. To mitigate this effect, GI or vegetated buffer areas tributary to the inlets will be proposed. These vegetated buffer strips and biofiltration devices can reduce pollutant loads that could potentially get into the storm drain.

The proposed discharge pipe into the Batiquitos Lagoon will require an Environmental Impact Assessment. Historically, discharging stormwater into the Lagoon has been a point of contention. As a result, the environmental permitting for this project should be considered early in the planning process prior to final design.

Exhibits 13 and 17 show the 100-year/24-hour maximum flooded depths (and difference from existing) for the proposed improvements. These are the maximum depths within the duration of the storm, and do not occur at the same time. Some areas will flood to these depths shown at varying times within the storm event. This map also assumes that the South Subarea storm drain system has been constructed and the existing 24-inch sluice gate remains in the open position during all storm events. In other words, no bifurcation or flows from the South subarea split out to the Vulcan subarea.

### Cost Estimate

Preliminary construction cost estimates were prepared for the future proposed addition of the Proposed Vulcan storm drain improvements. The detailed cost estimates are included in Table 6-1 and only show the Vulcan backbone infrastructure. Summarized lateral cost estimates are provided in Table 6-2.

**Table 6-1: Vulcan Main-Line Mitigation Measures – Cost Estimate**

| Item No.  | Item Description                                     | PROJECT TOTAL   |                      |            |                     |
|---|--|-----------------|----------------------|------------|---------------------|
|   |  | Unit of Measure | Estimated Quantities | Unit Price | Item Total          |
| 1   | Install 18-inch RCP                                  | LF              | 234                  | \$180      | \$42,120            |
| 2   | Install 36-inch RCP                                  | LF              | 2,299                | \$320      | \$735,680           |
| 3   | Install 48-inch RCP                                  | LF              | 388                  | \$490      | \$190,120           |
| 4   | Install 60-inch RCP                                  | LF              | 2,951                | \$700      | \$2,065,700         |
| 5   | Install 66-inch RCP                                  | LF              | 1,018                | \$850      | \$865,300           |
| 6   | Install 72-inch RCP                                  | LF              | 3,228                | \$1,000    | \$3,228,000         |
| 7   | Catch Basin Inlets                                   | EA              | 34                   | \$7,000    | \$238,000           |
| 8   | Install Energy Dissipator Outfall                    | EA              | 1                    | \$50,000   | \$50,000            |
| 9   | Removal of 24-inch Outlet Pipe                       | LS              | 1                    | \$5,000    | \$5,000             |
| 10  | Junction Structures                                  | EA              | 3                    | \$15,000   | \$45,000            |
| 11  | Manhole  | EA              | 33                   | \$7,000    | \$231,000           |
| 12  | Green Infrastructure (Assume Vegetated Buffer Areas) | SF              | 57,000               | \$10       | \$570,000           |
| 13  | Porous Pavers  | SF              | 20,000               | \$20       | \$400,000           |
| 14  | Media Filter Type BMP (Incl. Pipe)                   | EA              | 1                    | \$100,000  | \$100,000           |
| <b>SUBTOTAL (CONSTRUCTION)</b>                                |  |                 |                      |            | <b>\$8,765,920</b>  |
| 15  | Mobilization (10%)                                   | LS              | 1                    | \$876,592  | \$876,592           |
| 16  | Engineering and Design (10%)                         | LS              | 1                    | \$876,592  | \$876,592           |
| 17  | Surveying (2%)                                       | LS              | 1                    | \$175,318  | \$175,318           |
| 18  | Traffic Control                                      | LS              | 1                    | \$50,000   | \$50,000            |
| 19  | Environmental & Permitting                           | LS              | 1                    | \$150,000  | \$150,000           |
| 20  | Construction Management (6%)                         | LS              | 1                    | \$525,955  | \$525,955           |
| <b>SUBTOTAL (ENGINEERING AND CONSTRUCTION ADMINISTRATION)</b> |  |                 |                      |            | <b>\$2,654,458</b>  |
| <b>SUBTOTAL COST</b>  |  |                 |                      |            | <b>\$11,420,378</b> |
| <b>CONTINGENCY</b>  |  |                 |                      | <b>20%</b> | <b>\$2,284,076</b>  |
| <b>TOTAL PROJECT</b>  |  |                 |                      |            | <b>\$13,704,453</b> |

Laterals V-1, V-2, and V-3 can be summed up in Table 6-2. Detailed cost estimates can be found in Appendix D.

**Table 6-2: Vulcan Laterals - Mitigation Measures – Cost Estimates**

| Lateral | Total Costs |
|---------|-------------|
| V-1     | \$2,980,896 |
| V-2     | \$3,753,466 |
| V-3     | \$593,424   |

**Table 6-3: Total Vulcan Subarea Mitigation Measures – Cost Estimate**

| Storm Drain                 | Cost                |
|-----------------------------|---------------------|
| Vulcan Main Line            | \$13,704,000        |
| Vulcan Laterals (V-1, 2, 3) | \$7,327,000         |
| <b>Total Estimated Cost</b> | <b>\$21,031,000</b> |

### 6.3 South Leucadia Subarea (Future Improvement)

The South Subarea is the smallest of the three western Leucadia subareas. Drainage within the watershed is routed southwest towards Vulcan Avenue where a majority of the runoff currently either pond along the street or along the east side of the NCTD railroad tracks near Union Street. Some of the runoff within the southern subarea drains south via Ocean View Avenue to Via Julita to Arroyo Drive where it eventually reaches Cottonwood Creek. This subarea also contains a low point that collects runoff at the upper end of Union Street.

A small portion of the South subarea drains towards the intersection of Union Street and Vulcan Avenue, adding to the current flood issue at that site. Some of the runoff from this subarea gets drained to the north via the existing 24-inch storm drain and sluice gate.

Historically, proposed alternatives have been reviewed that route flows south towards Cottonwood Creek and Moonlight Beach, which is also the discharge for the Old Encinitas subarea. Previous studies showed that Cottonwood Creek currently is undersized and has significant environmental restrictions. Moonlight Beach also has a history of poor water quality, particularly elevated levels of Enterococci bacteria.

A study performed by Southern California Coastal Water Research Project, (SCCWRP) *San Diego County Enterococcus Regrowth Study*, in January of 2012 (Griffith and Ferguson, 2012), looked into the source of these high bacterial counts along two specific beach outfalls. One of these outfalls was Moonlight Beach. In summary, the study suggested that the source of the *Enterococci* bacteria was primarily due to the natural processes within the channel itself. In particular, the study focused on in-stream vegetation, seawrack, and algae and its ability to produce *Enterococcus*. A secondary source that studied was birds and insects and their role as a potential source of *Enterococcus*. The result showed high likelihood that the bacteria identified was most likely due to the natural breakdown of these elements. Bird droppings also showed a high potential as a secondary source.

Discharging additional flows into Cottonwood Creek, could induce additional bacterial growth within the channel (via addition of low flow volume), and wash more of the in-stream bacteria out into the beach. Adding more flows to Cottonwood Creek would not only over capacitate the lower reaches of the flood control system, but it could also adversely impact the water quality at the outfall. Due to these factors, it is recommended to discharge the South Leucadia subarea flows directly at the beach.

This study did not review the hydraulic capacity of Cottonwood Creek, as this system is a County and US Army Corps of Engineers structure. Most of the facility was modeled to establish a tailwater condition for some of the City-owned laterals that tie into it. None of the regional proposed solutions tie into Cottonwood Creek directly.

Multiple alternatives were evaluated with respect to backbone drainage alignments and type of system. Both grey (typical drainage infrastructure) and green infrastructure alternatives were evaluated. Green

infrastructure (by itself) does not provide flood control protection for moderate to large storm events but was found to reduce runoff and provide potential water quality treatment for small storm events. The proposed alternative selected consists of a mixture of both green and grey infrastructure.

**Proposed Flood Control Facilities:**

The first phase of the L101 Streetscape project is located within this subarea. Phase 1 of Streetscape includes the L101 south to B Street. These proposed improvements were considered as part of this study and recommended measures. The L101 project proposes to place new storm drain along North Coast Hwy, that eventually ties into the existing drainage system near the intersection of North Coast Hwy and B Street. This study proposes to extend the proposed storm drain, and also add a larger system along Vulcan Avenue to route flows south. Further details of the L101 project and proposed storm drain systems in this area will be highlighted in the Final Design Report and Final Calculations of the L101 project. The following Figures and lateral representations are not final, and will be reviewed as part of the L101 project.

Figure 6-7 shows the configuration of the proposed storm drain infrastructure improvements for the South Subarea. Existing and newly constructed (L101 Project) storm drain is also highlighted on this map. These improvements were evaluated and sized based on the implementation of green infrastructure at location identified based on available space. The main line backbone for the South Leucadia storm drain has been detailed in Exhibit 2.

The main storm drain begins at Vulcan Avenue and Union Street and extends south along Vulcan Avenue to B Street, where it traverses west to Moonlight Beach. The proposed storm drain ranges from 24-inch to 48-inch RCP. The total length of the system is approximately 5,000 linear feet. The system outfalls into a small basin that feeds into two existing RCP pipes that outfall onto Moonlight Beach.

This new proposed main line would also intercept the two existing storm drains along North Coast Highway. Currently, these two systems tie into Cottonwood Creek, but this alignment would capture these flows to allow for low flow diversion and future treatment (see discussion below).

The depth of cover for this proposed system ranges from 2 feet to over 30 feet along Vulcan Avenue. Although the proposed storm drain is deep, the alternative alignment was selected due to the reduced impacts to existing facilities. This alignment also present opportunity for more water quality treatment.

Lateral S-1: The proposed lateral S-1 extends from the upper reach of Union Street, down Orpheus and ties into the main line at Orpheus and Vulcan. The primary function of this lateral is to de-flood the low point near the upper Union Street/Orpheus Avenue intersection.

Lateral S-2: Lateral S-2 joins the newly constructed system along the North Coast Highway. This lateral proposes to extend the newly constructed storm drain north up L101 to Marchetta Street, approximately 350 feet. From here it extends 270 feet up Marchetta Street.

Exhibits 13 and 17 show the graphical results for the 100-year, 50-year, 10-year, and 5-year XPStorm model proposed conditions. These exhibits show the ultimate maximum depth results for each respective storm event. These results show the maximum depth that occurs in any given time throughout the storm event. These depths do not occur simultaneously.







**Future Design Considerations:** Future analyses should consider extending this proposed outfall to a new headwall that joins the Cottonwood Creek headwall. Current conditions of this outfall for Cottonwood Creek and the dual RCP pipe headwalls are deteriorating and will soon need to be improved. In addition, the existing dual RCP pipe headwall is currently exposed due to coastal erosion.



*Cottonwood Creek Outfalls at Moonlight Beach*

An alternative design would be to pull back the dual pipe outfall to join the triple RCB headwall. This new headwall could reduce the overall “engineered” footprint at the beach, minimizing the environmental impacts of the facility. During this future site evaluation, the outfall (main proposed outlet headwall) alignment could be reevaluated to further minimize environmental impact and provide more accessible recreational area within the beach.

Section 6.5 discusses additional considerations for the South drainage system.

#### **Water Quality:**

To treat the flow prior to discharge, a three-pronged approach is recommended to provide water quality treatment; 1) Green infrastructure in the form of vegetated buffer strips and biofiltration is proposed along Vulcan Avenue; 2) A structural water quality treatment facility is proposed at (or near) the intersection of Vulcan Avenue and Encinitas Boulevard (adjacent to the NCTD right-of-way); and 3) A proposed nuisance flow diversion system to be implemented near the current treatment and pump station at 3<sup>rd</sup> Street and B street.

Subject to change in the final design, the goal for green infrastructure is to mimic, but not exceed, the current infiltration characteristics due to the recommendations provided in a prepared by Dudek, “Encinitas and Leucadia Watersheds Preliminary Stormwater Infiltration Hazard Zones”, November 15, 2019.

By developing better infrastructure to route storm runoff, it is expected that large storm peak discharges will increase, as flows are being routed more hydraulically efficiently. Some increase in runoff volume is also expected at the outfall since flows that were once tributary to the existing 24-inch sluice gate system, are not being diverted to the Moonlight Beach. Although more flow is being diverted, it is proposed to undergo water quality treatment prior to discharge. The amount of proposed (treated) flow that the South Subarea discharges to the beach compared to the overall tributary drainage area of Cottonwood Creek is not expected to impair water quality standards at the beach. Especially since the prime source of bacteria historically identified at the beach has actually been estimated to come from the natural creek (Cottonwood Creek) itself (SCCWRP, 2012).

Currently flows along North Coast Highway and the neighborhoods immediately to the west drain to either Cottonwood Creek. These flows are mostly untreated. The alternative in this study proposes to treat flows from east (and along) Vulcan Avenue using vegetated buffer areas, or biotreatment. Once in the pipe, a proposed media filter is planned at the intersection of Encinitas Blvd. and Vulcan Avenue. One of two potential sites have been identified at the earthen parking area adjacent to the NCTD overpass, and one location at the corner of Cottonwood Creek park. Both sites will require an underground vault-type

treatment facility that can be covered. The park provides a better location based on topography. The facility can be planted over except for the maintenance or access shaft. The site adjacent to the NCTD railroad is sloped and would require retaining walls to provide a flat surface for the facility.

Flows along Vulcan Avenue are proposed to be treated with vegetated buffer areas and/or biotreatment located along the sides of the road. These facilities are designed to treat the “first flush”. A downstream diversion structure will route all low-flows (nuisance flows) to a new pump station that will route flows south to the Cardiff Treatment plant.

The future proposed pump station will be coordinated with SEJPA and divert dry-weather flow, and potentially some runoff (less than 1-year storm) to a new pump station located next to the current treatment station/pump station site located at the southeast corner of the 3<sup>rd</sup> Street and B Street intersection. Exhibit 2 the location of proposed GI, treatment facilities, and the diversion structure. The maximum amount of flow to be diverted is still under negotiation. The goal of the diversion is not to mitigate flood control, but rather water quality.

Coordination with SEJPA during this study has helped identify best potential diversion locations and allowed the City to contribute to the planning of SEJPA current and future projects for stormwater reuse. This coordination has laid the foundation for the potential to divert more flow than originally planned.

The discharge pipe and alignment from the proposed pump station to the Cardiff Treatment plant is still under investigation but will most likely require a force main to be constructed south along 3<sup>rd</sup> Street, east along West D Street, and south along South Vulcan Avenue where it would tie into the existing sewer system or be routed to a new location. The estimated cost for this pump and discharge system is not currently been vetted and will not be a part of this study cost estimate.

### **Cost Estimate**

Preliminary construction cost estimates were prepared for the future proposed addition of the Proposed South storm drain improvements. The detailed cost estimates are included in Table 6-4 and only show the Vulcan backbone infrastructure. Summarized lateral cost estimates are provided in Table 6-5.

**Table 6-4: South Leucadia Main Line Mitigation Measures – Cost Estimate**

| Item No.  | Item Description                                     | PROJECT TOTAL   |                      |            |                    |
|---|--|-----------------|----------------------|------------|--------------------|
|   |  | Unit of Measure | Estimated Quantities | Unit Price | Item Total         |
| 1   | Install 24-inch RCP                                  | LF              | 68                   | \$250      | \$17,000           |
| 2   | Install 36-inch RCP                                  | LF              | 1,389                | \$320      | \$444,480          |
| 3   | Install 42-inch RCP                                  | LF              | 2287                 | \$430      | \$983,410          |
| 4   | Install 48-inch RCP                                  | LF              | 1092                 | \$490      | \$535,080          |
| 5   | Install Outfall Structure                            | EA              | 1                    | \$20,000   | \$20,000           |
| 6   | Junction Structures                                  | EA              | 1                    | \$9,000    | \$9,000            |
| 7   | Catch Basin Inlets                                   | EA              | 5                    | \$8,000    | \$40,000           |
| 8   | Manhole  | EA              | 12                   | \$7,000    | \$84,000           |
| 9   | Green Infrastructure (Assume Vegetated Buffer Areas) | SF              | 26,000               | \$10       | \$260,000          |
| 10  | Low Flow Diversion Structure                         | EA              | 1                    | \$20,000   | \$20,000           |
| 12  | Extension Outlet 5'Hx10'W RCB (Optional)             | CY              | 300                  | \$1,000    | \$300,000          |
| 13  | Ocean Outfall Structure - Large (Optional)           | LS              | 1                    | \$150,000  | \$150,000          |
| 14  | Erosion Protection at Outfall (Optional)             | LS              | 1                    | \$100,000  | \$100,000          |
| 11  | Media Filter Type BMP (Incl. Pipe)                   | LS              | 1                    | \$50,000   | \$50,000           |
| <b>SUBTOTAL (CONSTRUCTION)</b>                                |  |                 |                      |            | <b>\$3,012,970</b> |
| 12  | Mobilization (10%)                                   | LS              | 1                    | \$301,297  | \$301,297          |
| 13  | Engineering and Design (10%)                         | LS              | 1                    | \$301,297  | \$301,297          |
| 14  | Surveying (2%)                                       | LS              | 1                    | \$60,259   | \$60,259           |
| 15  | Traffic Control                                      | LS              | 1                    | \$30,000   | \$30,000           |
| 16  | Environmental & Permitting                           | LS              | 1                    | \$150,000  | \$150,000          |
| 17  | Construction Management (6%)                         | LS              | 1                    | \$180,778  | \$180,778          |
| <b>SUBTOTAL (ENGINEERING AND CONSTRUCTION ADMINISTRATION)</b> |  |                 |                      |            | <b>\$1,023,632</b> |
| <b>SUBTOTAL COST</b>  |  |                 |                      |            | <b>\$4,036,602</b> |
| <b>CONTINGENCY</b>  |  |                 |                      | 20%        | <b>\$807,320</b>   |
| <b>TOTAL PROJECT</b>  |  |                 |                      |            | <b>\$4,843,922</b> |

Laterals S-1 and S-2 can be summed up in Table 6-5. Detailed cost estimates can be found in Appendix D.

**Table 6-5: South Leucadia Laterals - Mitigation Measures – Cost Estimates**

| Lateral | Total Costs |
|---------|-------------|
| S-1     | \$1,117,690 |
| S-2     | \$146,592   |

And the total system cost is estimated in Table 6-6.

**Table 6-6: Total Vulcan Subarea Mitigation Measures – Cost Estimate**

| Storm Drain                 | Cost               |
|-----------------------------|--------------------|
| South Main Line             | \$4,844,000        |
| South Laterals (S-1, S-2)   | \$1,264,000        |
| <b>Total Estimated Cost</b> | <b>\$6,108,000</b> |

## 6.4 East Leucadia Subarea (Future Improvement)

The East Subarea is less urbanized than the west Leucadia subareas. Most of the development to the east of the I-5 freeway were constructed in the 1980s, with typical curb and gutter type street sections and drainage catch basin inlets. Most of the development is constructed along the hillsides, where stormwater runoff is drained down to one of four canyons and eventually out to Batiquitos Lagoon. Within the East Leucadia subarea, Encinitas Creek drains a majority of the area west and approximately half of the area east of the I-5 freeway. The remaining areas to the east drain into the canyons and ultimately out into Batiquitos Lagoon.

Existing condition hydrology/hydraulic models were prepared and showed no major (regional) flooding issues within this watershed. Coordination with the City confirmed these findings. As a result, no proposed flood control improvements were required for this area.

### Water Quality:

In the late 1990s, Caltrans as part of a Water Quality Retrofit Pilot project constructed a wet-basin water quality treatment facility at the northbound offramp to La Costa Avenue. This facility is designed to treat runoff from Encinitas Creek prior to discharging into the lagoon. The facility treats dry weather flow using a diversion within the creek.

Flows along the far east side of the subarea drain into one of two canyons. These canyons convey flows through a natural channel that runs north into Batiquitos Lagoon via culverts under La Costa Avenue. These long natural drainage courses provide more “natural” treatment than a typical engineered drainage system. Natural channels induce percolation, while the natural vegetation provides nutrient uptake. Desilting basins were constructed at the mouth of each canyon, prior to discharging into Batiquitos Lagoon.

As part of this study, green infrastructure locations were evaluated on a concept level. Green infrastructure in the form of vegetated buffer strips and biofiltration is proposed along roadway sections and open spaces typically benefit the watershed by replacing typically impervious areas with pervious solutions. Exhibit 18 shows a sample of some of the potential locations. Although no regional storm drain systems were proposed for this area, green infrastructure concepts were defined for further study. Refer to Appendix C to see the digital locations.

## 6.5 Union Street/Vulcan Avenue Special Flood Area Discussion

One of the areas that currently experiences the most chronic flooding within the Leucadia Subarea is the area near the intersection of Union Street and Vulcan Avenue, which bisects the subareas of Vulcan and South Leucadia. The proposed mitigation for this area consists of three different storm drain systems, due to the flooded area’s location with respect to a viable receiving water.

The current method for deflooding the Union area is via the 24-inch sluice gate and storm drain that diverts flows north along the North Coast Hwy. and discharges into the Ponto Beach basins. Due to size, distance, and lack of slope, the capacity for this system is very low compared to the amount of runoff that accumulates at this location. The current system works more like a drain pipe rather than a flood mitigation system. The current 24-inch storm drain also is connected to multiple systems along the North Coast Hwy. (L101 area), which creates a surcharge affect during storm events in excess of a 2-year/24hr event.

One of the main design issues with deflooding this area, is its distance and lack of available slope to a receiving water body. To capture and route storm water runoff would require increasing the storm drain sizes beyond what is feasible to construct. But splitting the required conveyance of flows among the existing 24-inch storm drain system, the Vulcan storm drain, and the South Leucadia storm drains allows for more feasible storm drain sizes. Since the 24-inch storm drain is already in the ground, it was proposed to keep the system intact (although disconnecting from downstream systems).

Figure 6-10. Union St./Vulcan Ave. Flooded Area Ultimate Storm Drain Configuration



This three-drain system configuration also allowed for the runoff to be dispersed among three different outfalls. By dividing the flows, no one receiving water would receive all the flows from the Union Street area.

Since the L101 project will be constructed first, the 24-inch existing system could become the Phase-1 drainage system for the Union Street/Vulcan Avenue area. Unlike previous operation, the 24-inch sluice gate could remain “fully open” during a storm event, which would drain the area more rapidly.

Previously, the sluice gate would remain “closed” or partially closed until the storm passed then opened to allow the area to slowly drain. This (Phase 1) would not eliminate the flooding at the area but will slightly reduce it. Then as the next two systems are constructed, the flooding impact of the area will be alleviated. This, of course would have to be verified in the XPStorm models as part of the Final Design hydraulics if the City wishes to pursue this option.

## **6.6 Old Encinitas Subarea (Future Improvement)**

The Old Encinitas Subarea is well urbanized. Similar to the West Leucadia subarea, much of the streets in areas west of the I-5 Freeway were constructed without curb and gutter. Areas east of the I-5 freeway were developed with curb and gutter. All of the runoff within the Old Encinitas watershed drains to Cottonwood Creek via several local storm drain systems.

Existing condition hydrology/hydraulic models were prepared and showed no major flooding issues within this watershed. Local pockets of flooding were identified but did not warrant a regional flood control facility to mitigate. Coordination with the City confirmed no major flooded area complaints have been received, which confirmed our findings. As a result, no main line storm drain proposed flood control improvements were required for this area.

### **Water Quality:**

The watershed was evaluated for potential green infrastructure improvements adjacent to the existing storm drain systems. Future Streetscape project could be planned to include GI facilities along the edge of pavement or within parking areas.

This subarea contains the Cottonwood Creek watershed. Most of the runoff within this area is captured in storm drain systems that eventually discharge into the creek. Cottonwood Creek extends east with a headworks located at the Encinitas Ranch golf course. Similar to previous discussion, Cottonwood Creek also collects runoff from a portion of the South Leucadia subarea.

An existing UV treatment facility located in Cottonwood Creek at the corner of 3<sup>rd</sup> and B Street, currently treats nuisance runoff from this area as well. The proposed South Leucadia diversion structure could potentially be retrofitted to account for flows from Old Encinitas, but future studies on the SEJPA system capacity will need to be performed to understand the amount of potential flow that can be diverted to their proposed Phase 2 treatment system. In this study, it is not recommended to divert nuisance runoff into this system until the capacity of the SEJPA system is analyzed.

## **6.7 Project Prioritization and Phasing**

A priority ranking has been developed in coordination with the City based on levels of system deficiencies and their impacts to public safety and property. The goal of the priority ranking is to determine the systems or areas most deficient, that pose the largest safety threat to identify which projects should be constructed first when funding becomes available.

Phasing can include constructing a portion of a recommended project, rather than incur the cost of constructing an entire project. Some of the recommended facilities identified in this study are costly and would require several sources of funding to implement. The goal of phasing is to define a systematic approach to identify which projects would provide the most incremental benefit to support the ultimate flood control design. For example, constructing downstream facilities first would provide some flood control and water quality benefits to the downstream areas. Improving upstream facility conveyance first, would provide no benefit downstream. In most cases, improving upstream conveyances first could adversely impact downstream areas. If upstream storage or reduction in runoff is viable, that project would improve conditions for the entire watershed if enough of the watershed runoff can be captured and stored to make a difference.

An area that shows high risk for public safety in highly traveled areas, such as main thoroughfares are prime candidates for priority 1 (highest). These areas can include problematic locations of frequent flooding that produce extensive property damage and traffic closures.

It should be noted that these priorities are geared towards an ultimate goal. This does not cover or include small infill drainage projects that can provide some minor flood control gains, but rather is focused on regional (“Big Water”) type of solutions.

Figure 6-11 shows the recommended prioritization of the proposed flood control improvement projects within the study area. Again, this exhibit focuses on the major areas of concern with respect to flooding. The Leucadia area contains all the prioritized improvements, as it is the area with the most flooding issues.

**Table 6-7: Priority Project Summary**

| Project              | Project                                 |
|----------------------|---|
| Priority 1 (Highest) | Vulcan Avenue SD Main Line              |
| Priority 2           | South Leucadia SD Main Line             |
| Priority 3*          | <i>Laterals V-1, V-2, V-3, S-1, S-2</i> |

*\*Note: Priority 3 Storm Drains should not be constructed prior to the main line improvements.*

The proposed flood control systems have been divided into three categories of priority, with Priority 1 being the highest. This diagram also functions as a phased implementation recommendation. The Vulcan main storm drain is the highest priority and if constructed first, would provide the largest flood mitigation benefit.

The Vulcan Avenue main line storm drain may be the highest priority but has the highest cost for implementation. Consequently, constructing this facility may be less economically feasible. Constructing the South Leucadia storm drain first will still provide a major benefit to the overall Leucadia area.

It should be noted that lateral improvements (Laterals V-1, V-2, V-3, S-1, and S-2) should NOT be completed until the downstream main line segments have been improved. Any improvement of these laterals prior to main line improvements could cause adverse flooding effects downstream. Lateral improvements should be evaluated using XPStorm to model the entire watershed to ensure not adverse impacts occur because of the proposed improvements.

Water quality projects are not prioritized in the same manner. Green infrastructure, structural water quality treatment facilities, and low flow diversion systems can be built as part of these systems or added at a future time. Facilities identified outside of these priority flood control projects should be constructed in the future as individual projects, or as part of streetscape or street reconstruction projects. Water quality requirements typically are associated with new construction, and or major facility modification projects.

Water quality facility treatment guidelines will be governed by the environmental resource agencies at the time of a particular project. Facilities will be implemented based on those requirements at the time of Final Design of each project.



## 7 CONCLUSIONS

The goal of this study was to evaluate the focused watersheds using a more advanced hydrologic and hydraulic approach to identify potential flood control mitigation measures. Several past studies were completed using older, more traditional analysis measures to identify proposed mitigation measures that concluded in infeasible alternatives. Although for the time, these studies provided the best available technologies to evaluate the drainage infrastructure, the City wanted a more comprehensive study to be performed using the latest technology in watershed analysis.

The study area (particularly the Leucadia area) presents a particularly difficult drainage dilemma. Much of area does not drain to a typical receiving water body. Several low points exist in the urbanized area of Leucadia. These low points collect runoff from storm events and cause extensive flooding for the residents in and around those areas. Much of the development and constructed storm drain infrastructure was in place prior to City incorporation. Much of the urbanized area contains older, less efficient, drainage infrastructure. These include less efficient drainage inlets, smaller storm drain lines, dry well facilities, and lack of curb and gutter within much of the residential streets. Many of the residents enjoy these curb-less street sections, as it provides a more rural feel for the older neighborhoods. Although these conditions may be more aesthetically appealing, they also create issues for controlling and conveying storm water runoff.

Currently, the City and its residents have created a program to combat these floods during medium to large storm events. Program actions during storm events include operation of manual sluice gates and mobilization of vacuum trucks and portable pump systems. The City also installed a small pump station along North Coast Highway to reduce flooding. This system provides some flood relief and without it, the flood damage would be much more significant. But, a system so highly dependent on personnel and system knowledge is susceptible to issues. One of the goals of this study is to identify flood control measures that do not require manual operation or a pump system to deflood the areas.

As part of this study, Q3 Consulting evaluated previous studies and their recommended flood control and green infrastructure measures. Development of proposed condition flood control models include a mixture of “grey” and “green” drainage infrastructure. Similar to previous studies, it was found that green infrastructure provides benefit during small storm events but does not provide relief for large storm events. Green infrastructure can reduce the amount of runoff within the watershed before it reaches the outlet. But during large events, the soil saturates relatively quickly, cause direct runoff to flow downstream.

Proposed storm drain improvements were focused on regional solutions, or “Big Water” solutions. Smaller projects that improve local (small) areas are encouraged, as long as they follow the general alignments of the regional proposed alternative solutions. In other words, if a local project proposes to divert runoff to another watershed or outlet, not outlined in this study, a regional XPStorm model analysis should be performed to ensure no adverse impacts to the immediate and adjacent systems.

Table 7-1 shows a cost summary of the different proposed regional storm drain system improvements. These numbers also include green infrastructure and water quality cost estimations.

**Table 7-1. Total Proposed Project Cost Estimate**

| <b>Storm Drain System</b> | <b>Improvement Costs<sup>1</sup></b> |
|---------------------------|--------------------------------------|
| Vulcan SD                 | \$21,032,000                         |
| South Leucadia SD         | \$6,108,000                          |
| <b>TOTAL</b>              | <b>\$27,140,000</b>                  |

The total estimated cost for green infrastructure and water quality is \$2,650,000 for all proposed systems. This number does not include the nuisance flow diversion and treatment project, which will be coordinated with SEJPA.

Tale 7-2 shows the costs for the different priority systems. The highest priority facilities include the main line drainage system along Vulcan Avenue. This system was estimated at approximately \$13.7 million. Once this system is in place, other systems could be built to tie into it (i.e. Laterals V-1, V-2, and V-3). The South Leucadia storm drain main, has a priority ranking of 2. It is recommended that this system is constructed before the S-1 and S-2 lateral systems.

**Table 7-2 Phased Construction Cost Estimate Summary**

| <b>Priority</b>      | <b>Improvement Costs<sup>1</sup></b> |
|----------------------|--------------------------------------|
| Priority 1 (Highest) | \$13,704,000                         |
| Priority 2           | \$4,007,000                          |
| Priority 3           | \$9,429,000                          |

The outfall of the South system should be evaluated to potentially combine with the existing Cottonwood Creek triple culvert outlet. This system is old and deteriorating and will need to be replaced soon. Combining these outfalls or creating one shared headwall for both the South Leucadia storm drain main and the Cottonwood Creek facility, would reduce the current footprint of proposed facility. This would be beneficial with the California Coastal Commission and the other regulatory agencies.

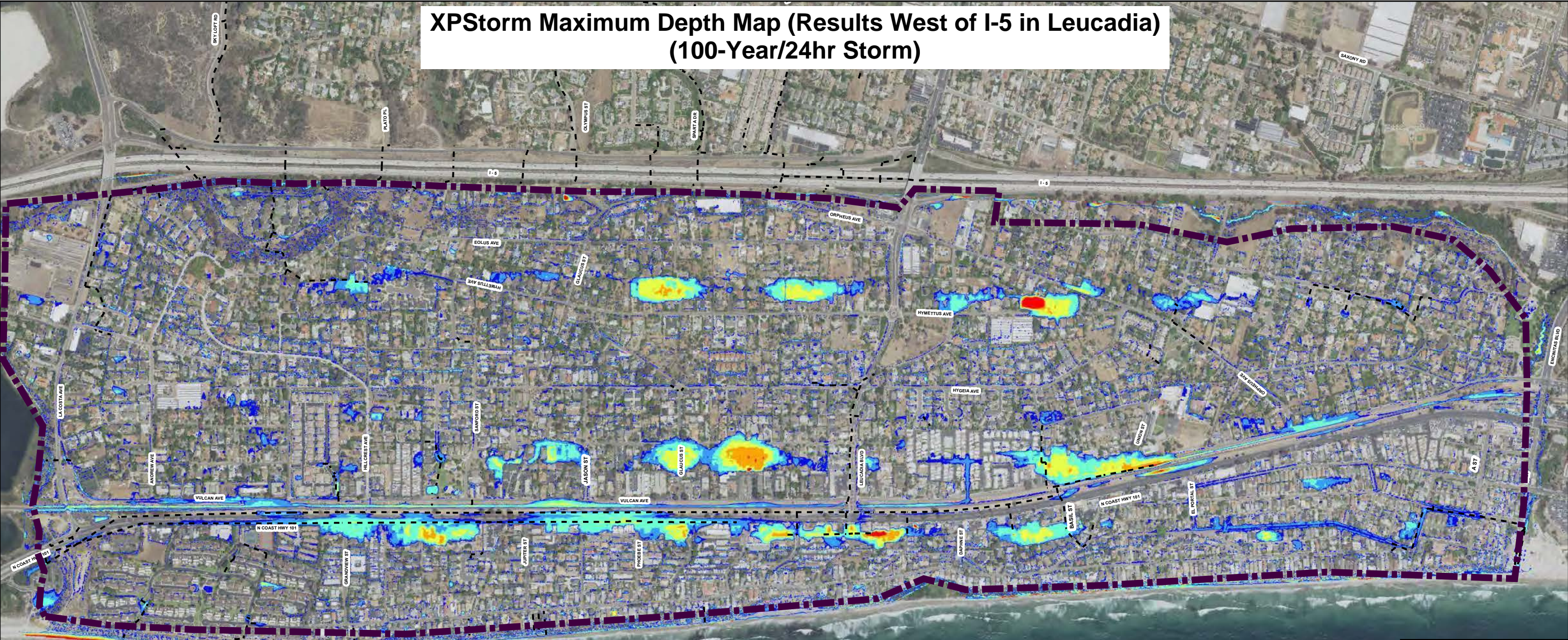
## **EXHIBITS**

Exhibits 1-12: Existing Condition Results-Maximum Depth Maps (XPStorm)

Exhibits 13-17: Proposed Condition Results – Max Depth Maps (XPStorm)

Exhibit 18: Green Infrastructure Potential Sites Maps

XPStorm Maximum Depth Map (Results West of I-5 in Leucadia)  
(100-Year/24hr Storm)



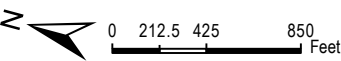
**MODEL BOUNDARY:** AREAS OUTSIDE OF THIS  
BOUNDARY ARE CALCULATED IN OTHER MODELS

**Legend**

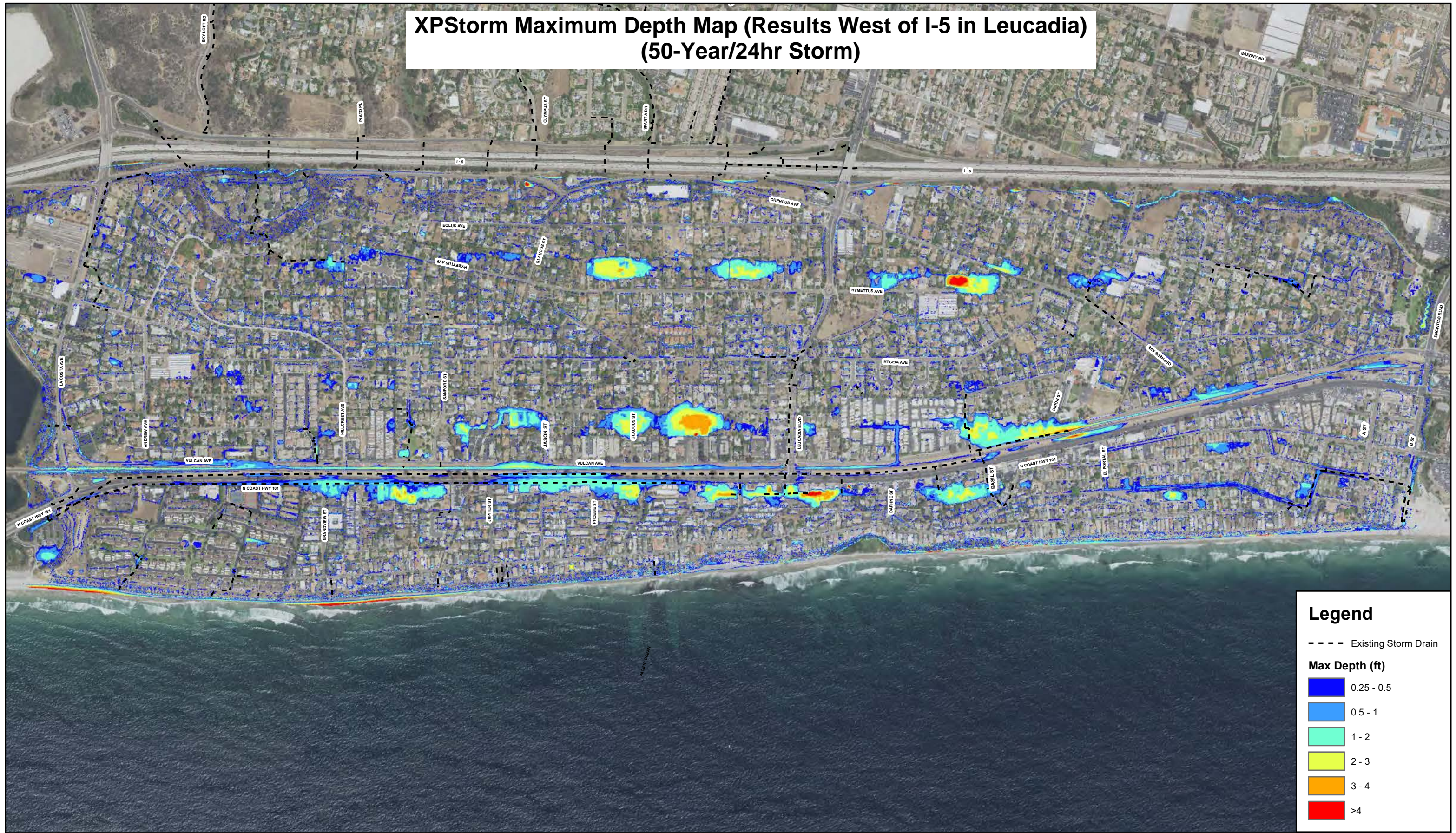
--- Existing Storm Drain

**Max Depth (ft)**

- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- >4



# XPStorm Maximum Depth Map (Results West of I-5 in Leucadia) (50-Year/24hr Storm)



**Legend**

--- Existing Storm Drain

**Max Depth (ft)**

0.25 - 0.5

0.5 - 1

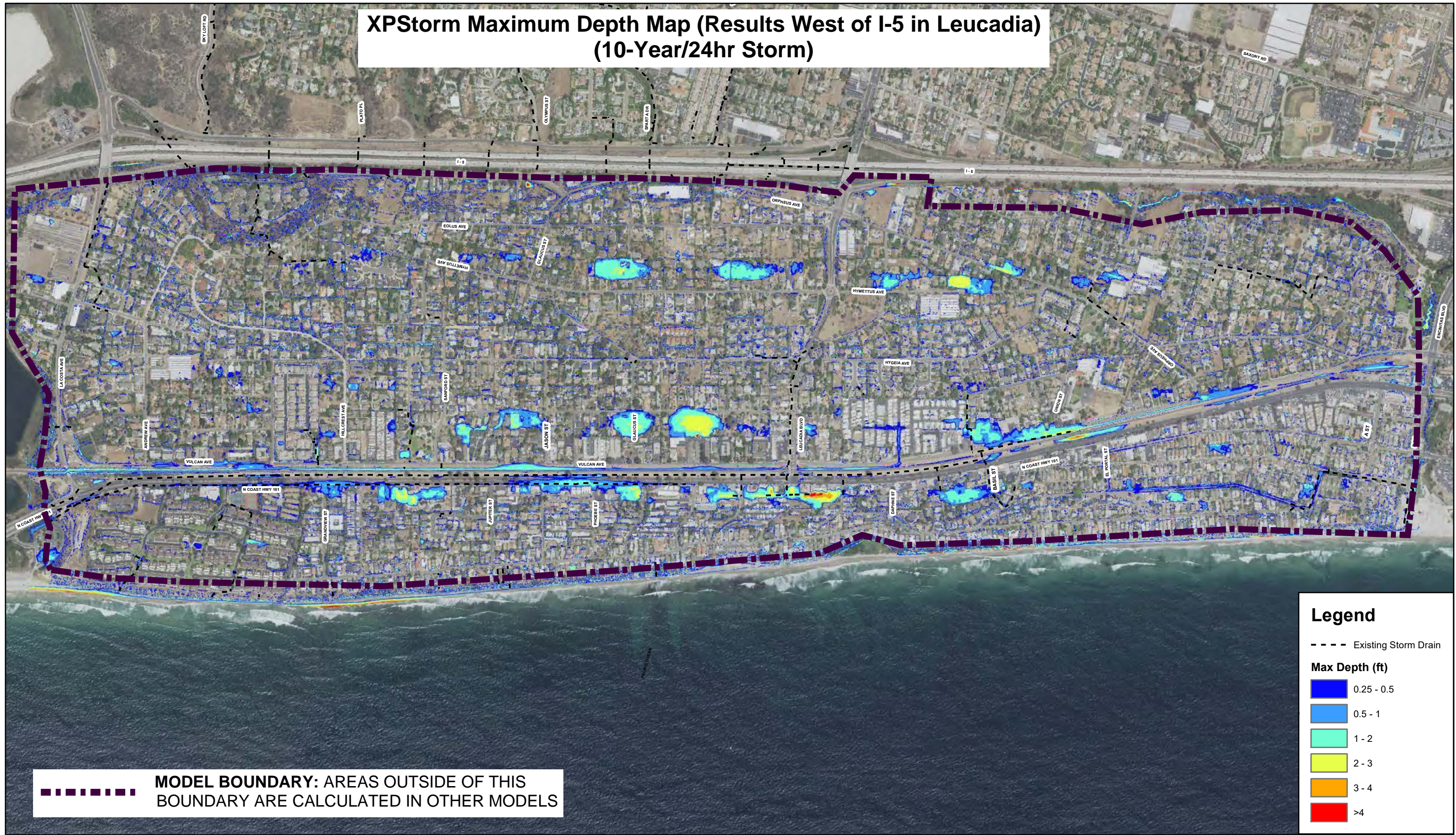
1 - 2

2 - 3

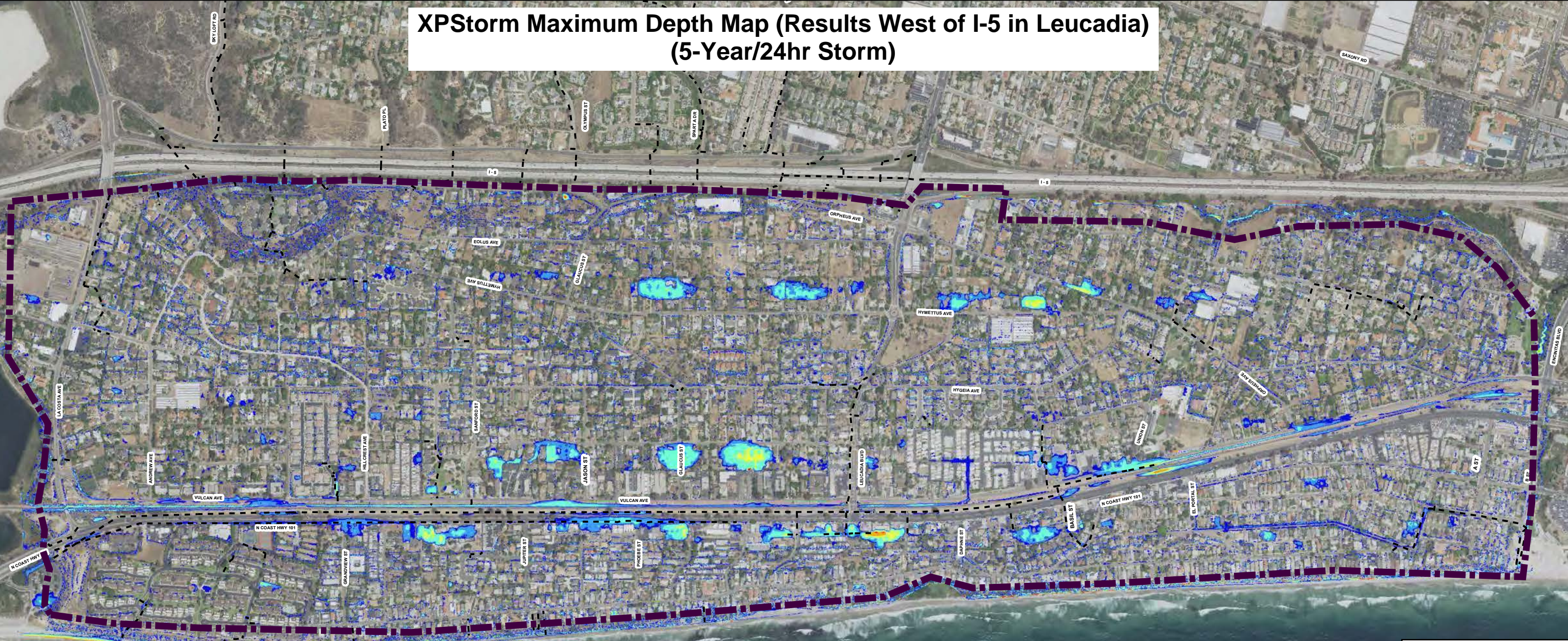
3 - 4

>4

# XPStorm Maximum Depth Map (Results West of I-5 in Leucadia) (10-Year/24hr Storm)



XPStorm Maximum Depth Map (Results West of I-5 in Leucadia)  
(5-Year/24hr Storm)



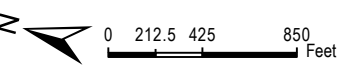
MODEL BOUNDARY: AREAS OUTSIDE OF THIS BOUNDARY ARE CALCULATED IN OTHER MODELS

**Legend**

--- Existing Storm Drain

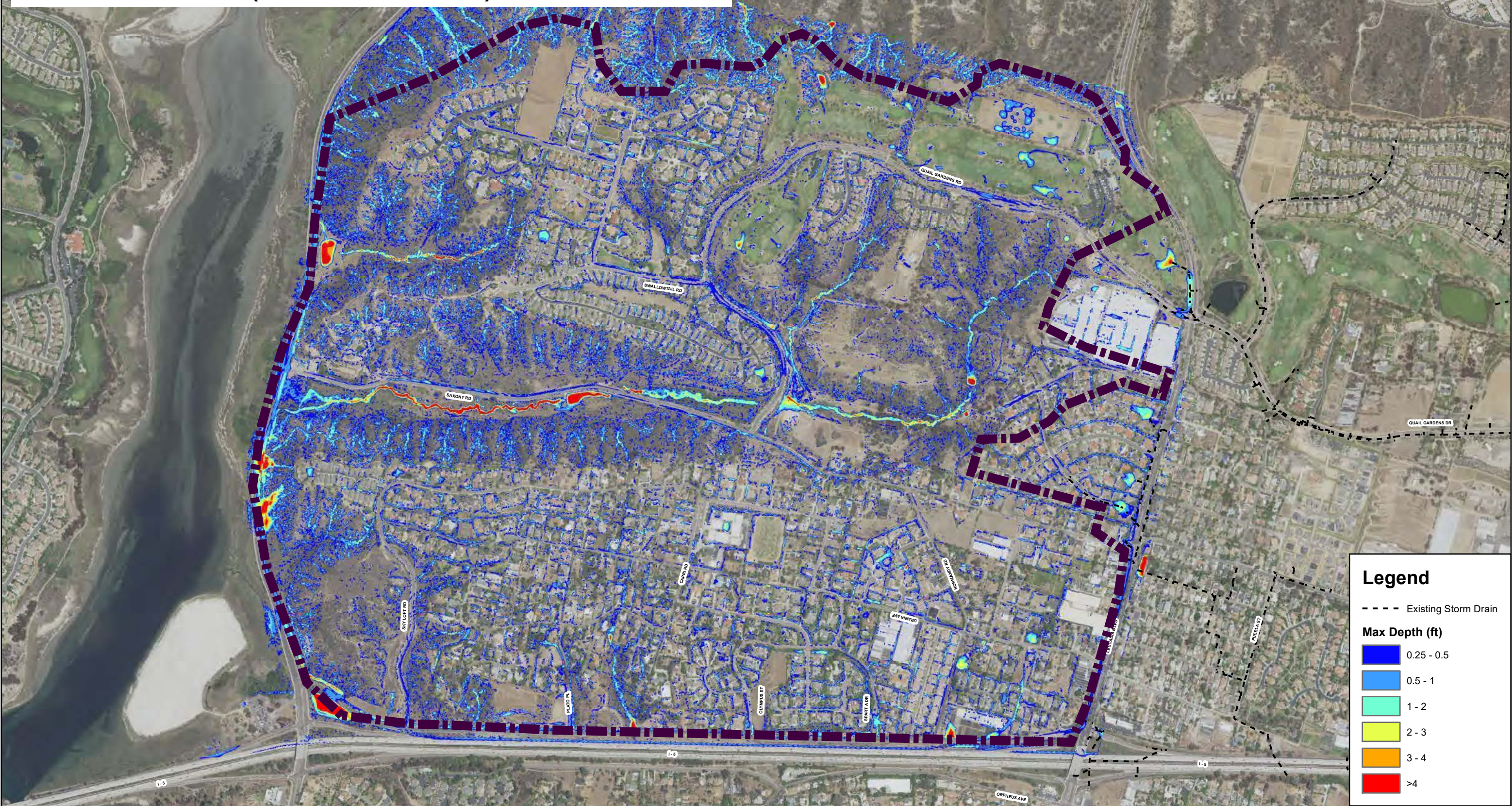
**Max Depth (ft)**

|             |            |
|-------------|------------|
| Blue        | 0.25 - 0.5 |
| Light Blue  | 0.5 - 1    |
| Light Green | 1 - 2      |
| Yellow      | 2 - 3      |
| Orange      | 3 - 4      |
| Red         | >4         |



**XPStorm Maximum Depth Map (Results East of I-5 in Leucadia)  
(100-Year/24hr Storm)**

MODEL BOUNDARY: AREAS OUTSIDE OF THIS  
BOUNDARY ARE CALCULATED IN OTHER MODELS



**Legend**

--- Existing Storm Drain

**Max Depth (ft)**

- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- >4

**XPStorm Maximum Depth Map (Results East of I-5 in Leucadia)  
(50-Year/24hr Storm)**

**MODEL BOUNDARY:** AREAS OUTSIDE OF THIS BOUNDARY ARE CALCULATED IN OTHER MODELS



**Legend**

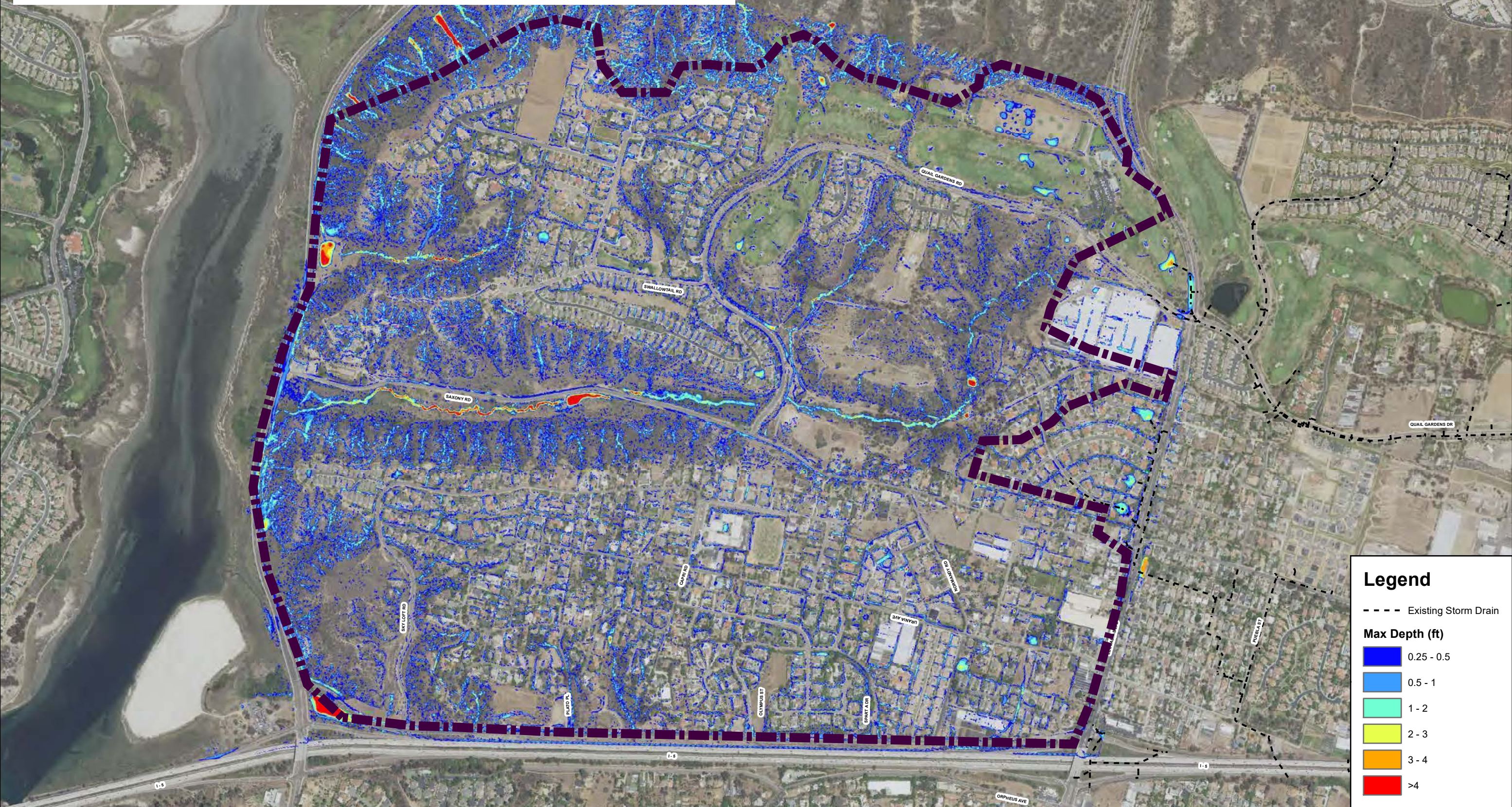
--- Existing Storm Drain

**Max Depth (ft)**

|            |            |
|------------|------------|
| Blue       | 0.25 - 0.5 |
| Light Blue | 0.5 - 1    |
| Cyan       | 1 - 2      |
| Yellow     | 2 - 3      |
| Orange     | 3 - 4      |
| Red        | >4         |

**XPStorm Maximum Depth Map (Results East of I-5 in Leucadia)  
(10-Year/24hr Storm)**

MODEL BOUNDARY: AREAS OUTSIDE OF THIS BOUNDARY ARE CALCULATED IN OTHER MODELS



**Legend**

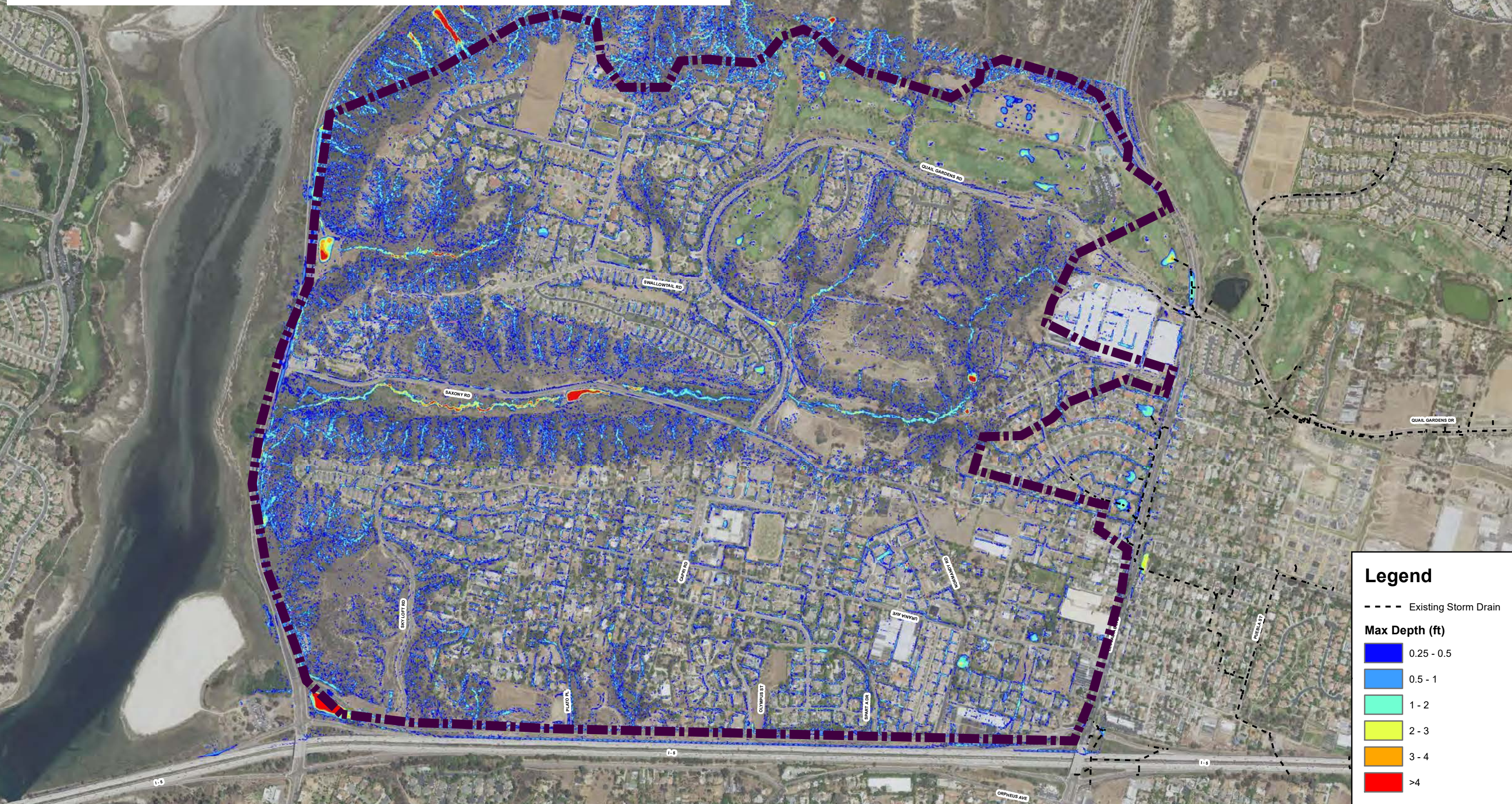
--- Existing Storm Drain

**Max Depth (ft)**

|            |            |
|------------|------------|
| Blue       | 0.25 - 0.5 |
| Light Blue | 0.5 - 1    |
| Cyan       | 1 - 2      |
| Yellow     | 2 - 3      |
| Orange     | 3 - 4      |
| Red        | >4         |

**XPStorm Maximum Depth Map (Results East of I-5 in Leucadia)  
(5-Year/24hr Storm)**

MODEL BOUNDARY: AREAS OUTSIDE OF THIS  
BOUNDARY ARE CALCULATED IN OTHER MODELS



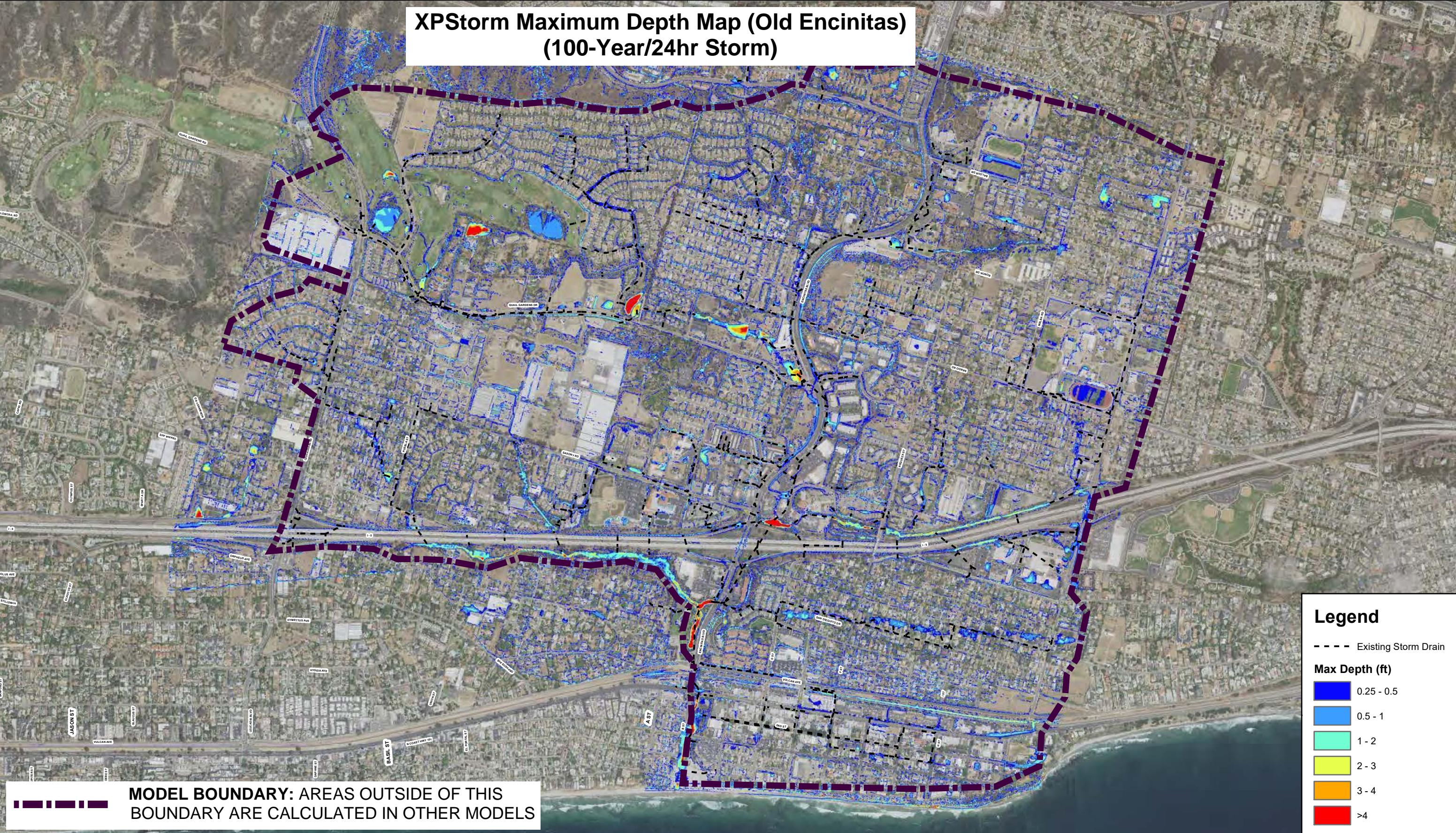
**Legend**

--- Existing Storm Drain

**Max Depth (ft)**

|             |            |
|-------------|------------|
| Blue        | 0.25 - 0.5 |
| Light Blue  | 0.5 - 1    |
| Light Green | 1 - 2      |
| Yellow      | 2 - 3      |
| Orange      | 3 - 4      |
| Red         | >4         |

**XPStorm Maximum Depth Map (Old Encinitas)  
(100-Year/24hr Storm)**



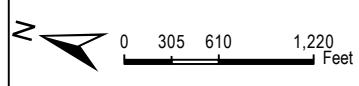
**Legend**

--- Existing Storm Drain

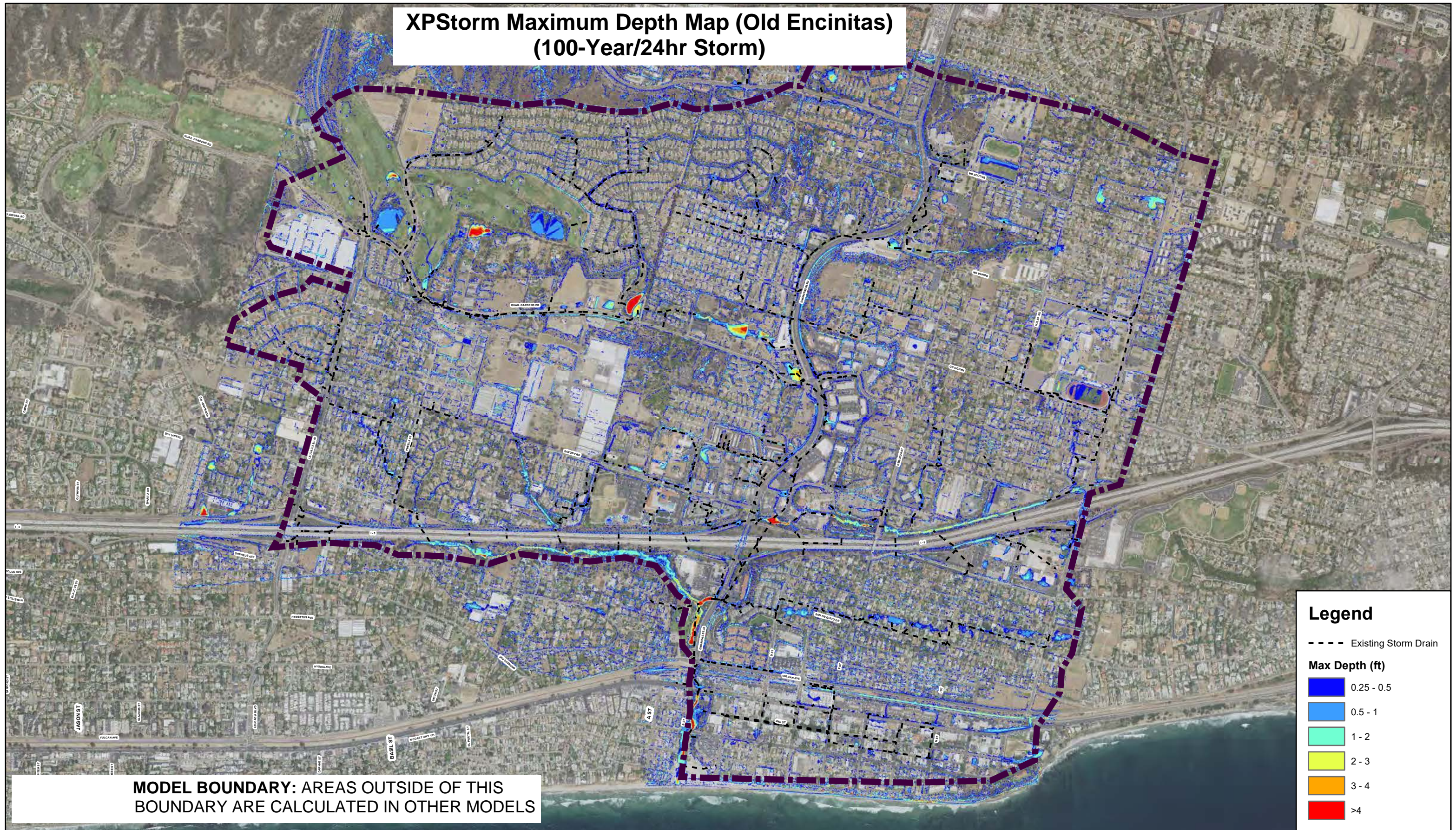
**Max Depth (ft)**

|            |            |
|------------|------------|
| Blue       | 0.25 - 0.5 |
| Light Blue | 0.5 - 1    |
| Cyan       | 1 - 2      |
| Yellow     | 2 - 3      |
| Orange     | 3 - 4      |
| Red        | >4         |

**MODEL BOUNDARY:** AREAS OUTSIDE OF THIS BOUNDARY ARE CALCULATED IN OTHER MODELS



# XPStorm Maximum Depth Map (Old Encinitas) (100-Year/24hr Storm)



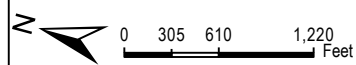
**Legend**

--- Existing Storm Drain

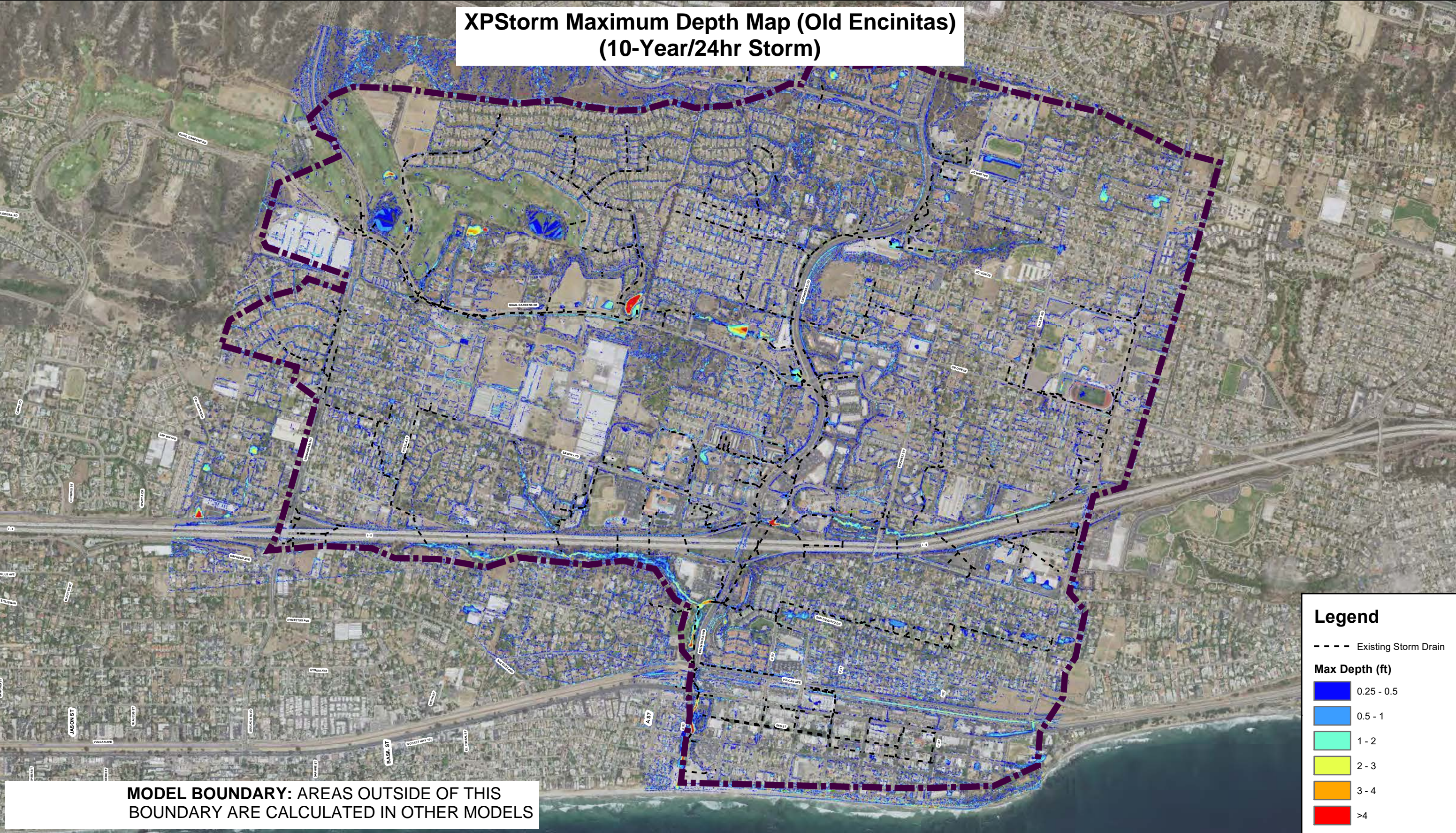
**Max Depth (ft)**

- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- >4

**MODEL BOUNDARY:** AREAS OUTSIDE OF THIS BOUNDARY ARE CALCULATED IN OTHER MODELS



# XPStorm Maximum Depth Map (Old Encinitas) (10-Year/24hr Storm)



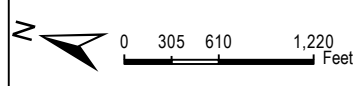
**Legend**

--- Existing Storm Drain

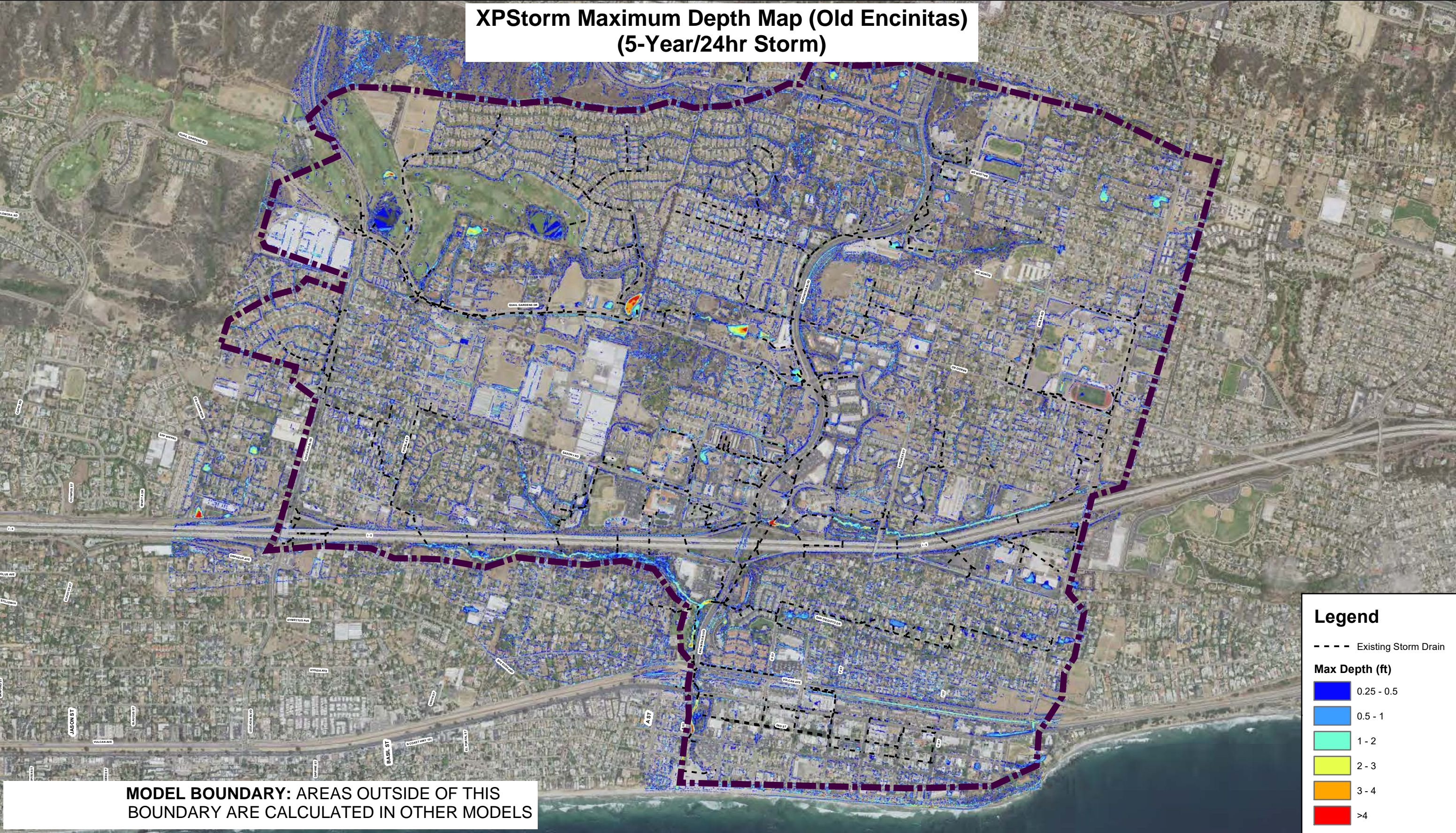
**Max Depth (ft)**

|            |            |
|------------|------------|
| Blue       | 0.25 - 0.5 |
| Light Blue | 0.5 - 1    |
| Cyan       | 1 - 2      |
| Yellow     | 2 - 3      |
| Orange     | 3 - 4      |
| Red        | >4         |

**MODEL BOUNDARY:** AREAS OUTSIDE OF THIS BOUNDARY ARE CALCULATED IN OTHER MODELS



# XPStorm Maximum Depth Map (Old Encinitas) (5-Year/24hr Storm)



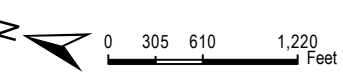
**Legend**

--- Existing Storm Drain

**Max Depth (ft)**

|            |            |
|------------|------------|
| Blue       | 0.25 - 0.5 |
| Light Blue | 0.5 - 1    |
| Cyan       | 1 - 2      |
| Yellow     | 2 - 3      |
| Orange     | 3 - 4      |
| Red        | >4         |

**MODEL BOUNDARY:** AREAS OUTSIDE OF THIS BOUNDARY ARE CALCULATED IN OTHER MODELS



**XPStorm Maximum Depth Map (Results West of I-5 in Leucadia)  
(100-Year/24hr Storm)**



**Legend**

— Proposed Storm Drain  
- - - Existing Storm Drain

**Max Depth (ft)**

|            |            |
|------------|------------|
| Blue       | 0.25 - 0.5 |
| Light Blue | 0.5 - 1    |
| Cyan       | 1 - 2      |
| Yellow     | 2 - 3      |
| Orange     | 3 - 4      |
| Red        | >4         |

# XPStorm Maximum Depth Map (Results West of I-5 in Leucadia) (50-Year/24hr Storm)



# XPStorm Maximum Depth Map (Results West of I-5 in Leucadia) (10-Year/24hr Storm)



## Legend

— Proposed Storm Drain

- - - Existing Storm Drain

### Max Depth (ft)

0.25 - 0.5

0.5 - 1

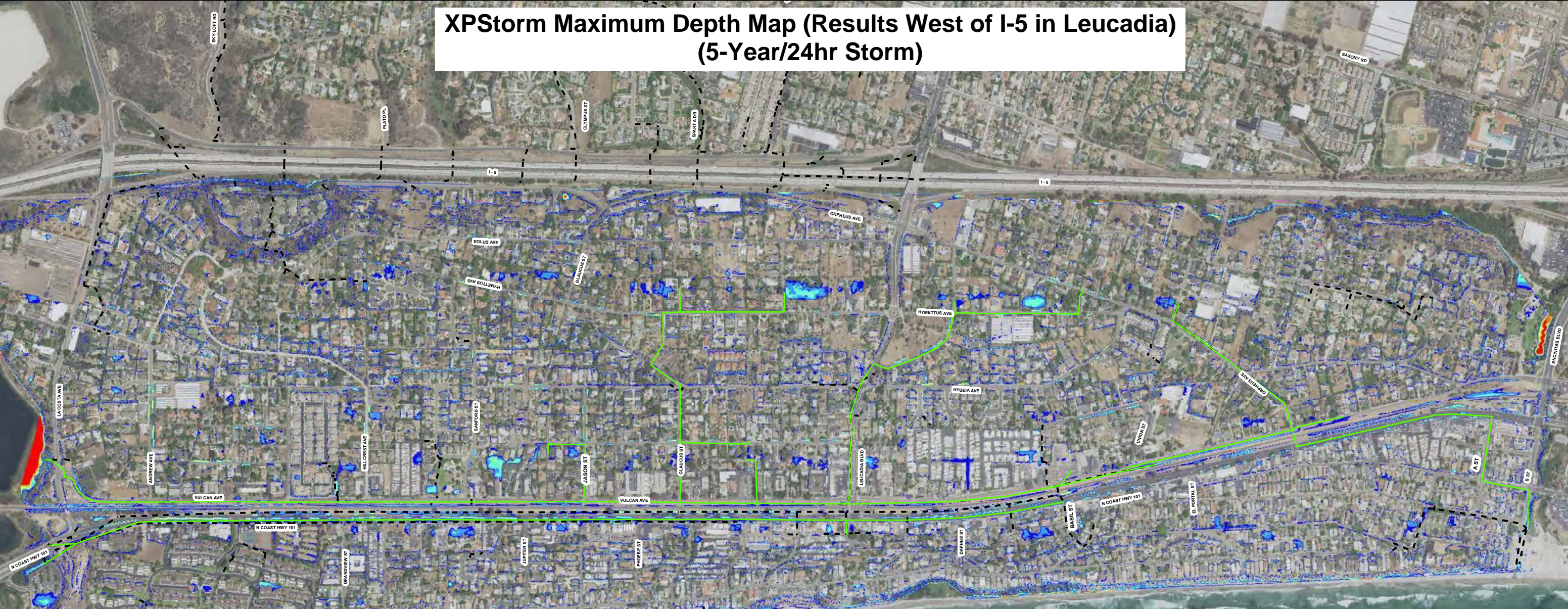
1 - 2

2 - 3

3 - 4

>4

**XPStorm Maximum Depth Map (Results West of I-5 in Leucadia)  
(5-Year/24hr Storm)**



**Legend**

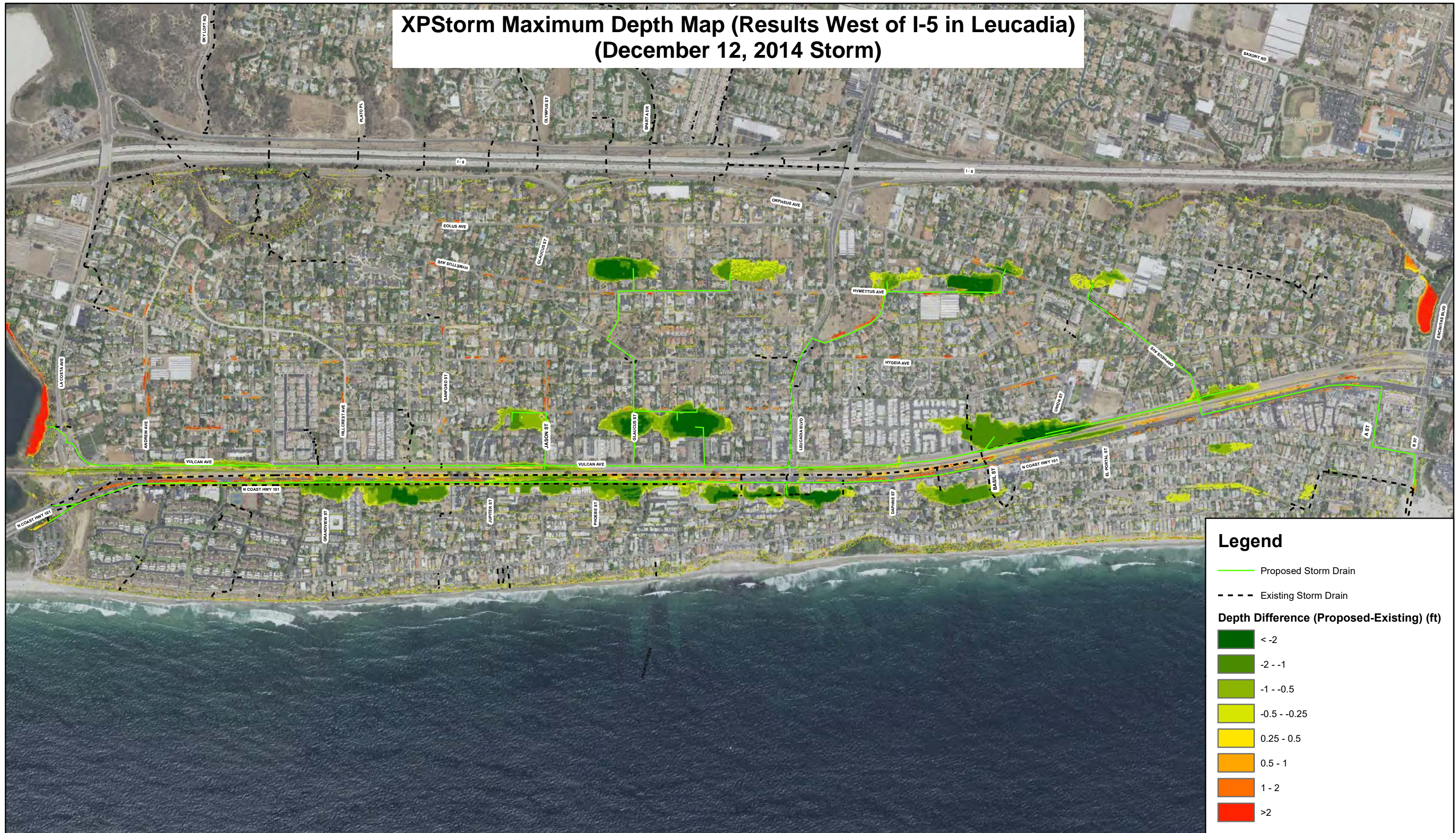
— Proposed Storm Drain

- - - Existing Storm Drain

**Max Depth (ft)**

- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- >4

**XPStorm Maximum Depth Map (Results West of I-5 in Leucadia)  
(December 12, 2014 Storm)**



**Legend**

— Proposed Storm Drain  
- - - Existing Storm Drain

**Depth Difference (Proposed-Existing) (ft)**

|              |              |
|--------------|--------------|
| Dark Green   | < -2         |
| Green        | -2 - -1      |
| Light Green  | -1 - -0.5    |
| Yellow-Green | -0.5 - -0.25 |
| Yellow       | 0.25 - 0.5   |
| Orange       | 0.5 - 1      |
| Red-Orange   | 1 - 2        |
| Red          | >2           |

## **TECHNICAL APPENDIX**

- A. Concept Plans
- B. Existing Condition Calculations
- C. Proposed Condition Calculations
- D. Order of Magnitude Construction Cost Estimates

## **APPENDIX A**

### **Concept Plans**

1. Vulcan Storm Drain System (Main Line)
2. South Leucadia Storm Drain System (Main Line)

## A.1 Vulcan Storm Drain System Concept Plans (Main Line)

# LEUCADIA WATERSHED FEASIBILITY STUDY

## VULCAN STORM DRAIN CONCEPT PLAN

### ABBREVIATIONS

|      |                          |       |                           |
|------|--------------------------|-------|---------------------------|
| AB   | AGGREGATE BASE           | PCC   | POINT OF CONTINUOUS CURVE |
| AC   | ASPHALT CONCRETE         | PP    | POWER POLE                |
| AS   | ASSESSOR'S PARCEL NUMBER | PR    | PROPOSED                  |
| ASR  | ASSESSOR'S RETURN        | PRC   | PROPOSED REVERSE CURVE    |
| BEG  | BEGIN CURB RETURN        | PRV   | PRESSURE REDUCING VALVE   |
| BVC  | BEGIN VERTICAL CURVE     | PVALT | PAVEMENT                  |
| C&G  | CURB & GUTTER            | RET   | RETAINING                 |
| CO   | CLEAN OUT                | RIM   | RIM ELEVATION             |
| CONC | CONCRETE                 | SCO   | SEWER CLEANOUT            |
| EC   | END CURVE                | SD    | STORM DRAIN               |
| ECR  | END CURB RETURN          | SDRGE | SAN DIEGO GAS & ELECTRIC  |
| EDGE | EDGE OF PAVEMENT         | SDRSD | SAN DIEGO REGIONAL        |
| EP   | END POINT                | SDRSD | STANDARD DRAINAGE         |
| EVC  | END VERTICAL CURVE       | SDRSD | STANDARD DRAINAGE         |
| EX   | EXISTING                 | SMH   | SEWER MANHOLE             |
| EX   | EXISTING                 | STD   | STANDARD                  |
| FL   | FINISH GRADE             | SV    | SEWER VALVE               |
| FS   | FINISH SURFACE           | SWK   | SIDEWALK                  |
| GV   | GAS VALVE                | TB    | TOP OF CURB               |
| HP   | HIGH POINT               | TS    | TRAFFIC SIGNAL            |
| IE   | INVERT ELEVATION         | WAS   | WATER AGENCIES' STANDARDS |
| LF   | LOW POINT                | WM    | WATER METER               |
| MB   | MAILBOX                  | WM    | WATER METER               |
| PC   | PORTLAND CEMENT CONCRETE |       |                           |

### BASIS OF COORDINATES

THE COORDINATES AND BEARINGS SHOWN HEREON ARE BASED UPON THE CALIFORNIA COORDINATE SYSTEM OF 1983 (CORS83) ZONE 6 (CORS EPOCH 2009.00). SAID COORDINATES AND BEARINGS ARE BASED LOCALLY UPON GLOBAL POSITIONING SYSTEM TIES TO THE FOLLOWING CONTINUOUS OPERATING REFERENCE STATIONS (CORS) AS PUBLISHED BY THE NATIONAL GEODETIC SURVEY (NGS). PUBLISHED POSITIONS FOR SAID STATIONS ARE BASED UPON THE NORTH AMERICAN DATUM OF 1983. (NAD83)

| STATION | NORTHING (ft.) | EASTING (ft.) |
|---------|----------------|---------------|
| P478    | 2030380.574    | 6310453.304   |
| DSWE    | 1958366.104    | 6255349.651   |

THE BASIS OF BEARINGS IS THE CALCULATED BEARING BETWEEN SAID CORN DSK & P478. I.E. N37°25'20"W

DISTANCES SHOWN HEREON ARE GROUND AND IN TERMS OF THE U.S. SURVEY FOOT. CONTROL POINT 100: GRID DISTANCE = GROUND DISTANCE X COMBINED SCALE FACTOR (0.99996899)

### SHEET INDEX

| SHEET | DESCRIPTION            |
|-------|------------------------|
| 1     | TITLE SHEET            |
| 2     | TYPICAL CROSS SECTIONS |
| 3-7   | STORM DRAIN PLANS      |

### SOURCE OF TOPOGRAPHY

TOPOGRAPHIC INFORMATION FOR THIS SURVEY IS PER MOBILE LIDAR SCANNING PERFORMED BY MICHAEL BAKER INTERNATIONAL IN NOVEMBER OF 2013 AND SUPPLEMENTED WITH CONVENTIONAL TOTAL STATION SURVEY INFORMATION FROM OCTOBER OF 2018 THROUGH JULY OF 2019.

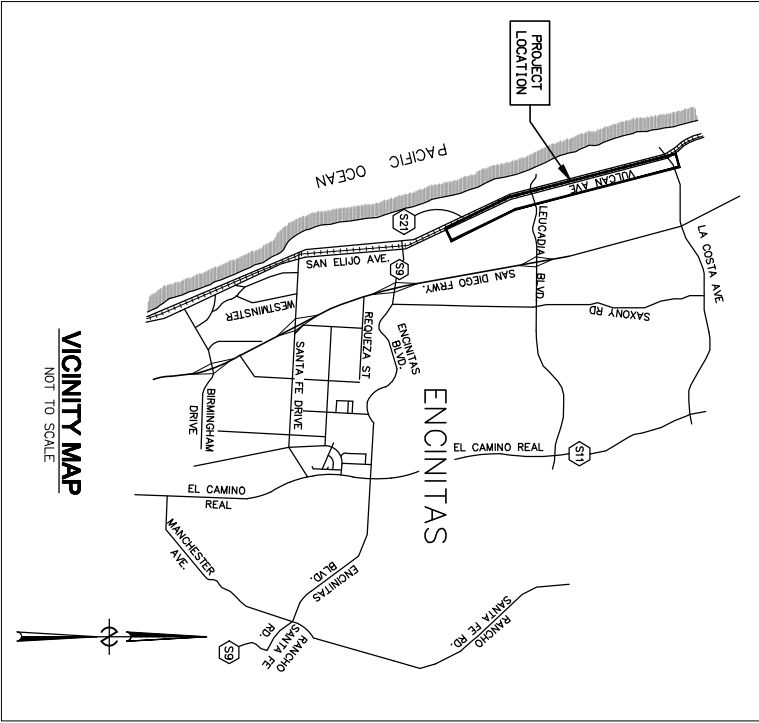
### BENCHMARK

THE BASIS OF ELEVATIONS FOR THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) PER RECORD OF SURVEY 18416 (CITY OF ENCINITAS SURVEY CONTROL). BENCHMARK DESIGNATION: POINT NUMBER 1004/ENC-4

ELEVATION: 67.639 (NAVD88)

### VICINITY MAP

NOT TO SCALE

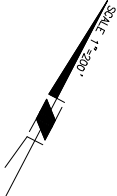
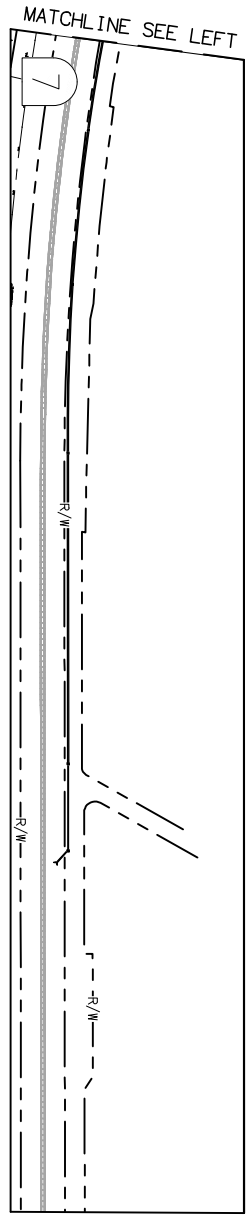
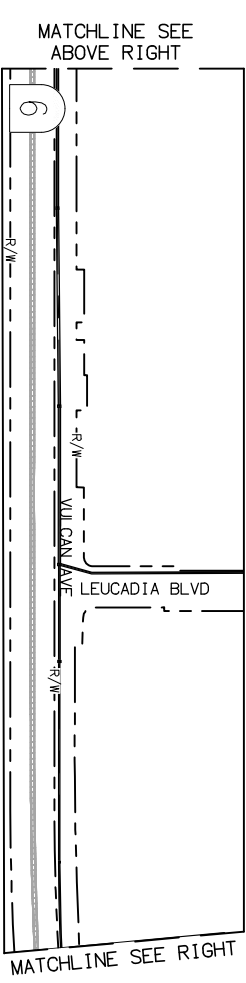
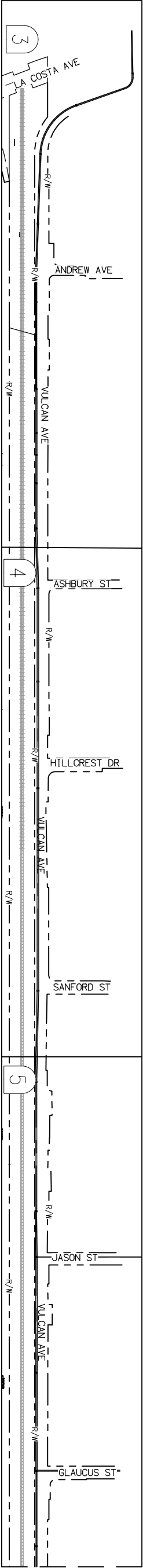


### PROJECT LOCATION

VULCAN AVENUE - UNION STREET TO LA COSTA AVE  
ENCINITAS, CALIFORNIA 92024

### LEGEND

| ITEM                          | STANDARD DWG | SYMBOL |
|-------------------------------|--------------|--------|
| EXISTING MEDIAN CURB          |              |        |
| RCP STORM DRAIN               |              |        |
| CURB INLET - TYPE A           |              |        |
| CURB INLET - TYPE B           |              |        |
| STORM DRAIN CLEANOUT - TYPE A |              |        |
| PROPOSED CONTOUR              |              |        |
| EXISTING CONTOUR              |              |        |
| DAYLIGHT LINE                 |              |        |
| 2:1 PROPOSED SLOPE            |              |        |
| NOTD LIMIT LINE               |              |        |
| EXISTING PROPERTY LINE        |              |        |
| STREET CENTERLINE             |              |        |
| EXISTING RIGHT OF WAY LINE    |              |        |
| EXISTING CONCRETE             |              |        |
| EXISTING EDGE OF PAVEMENT     |              |        |
| EXISTING WALL                 |              |        |
| EXISTING FENCE                |              |        |
| EXISTING WATER VALVE          |              |        |
| EXISTING FIRE HYDRANT         |              |        |
| EXISTING WATER METER          |              |        |
| EXISTING SEWER MANHOLE        |              |        |
| EXISTING SIGN                 |              |        |
| EXISTING STREET LIGHT         |              |        |
| EXISTING STORM DRAIN          |              |        |
| EXISTING SEWER LINE           |              |        |
| EXISTING WATER LINE           |              |        |
| EXISTING GAS LINE             |              |        |



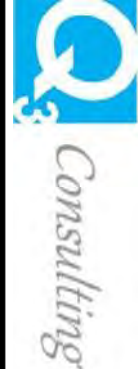
### INDEX MAP LEGEND

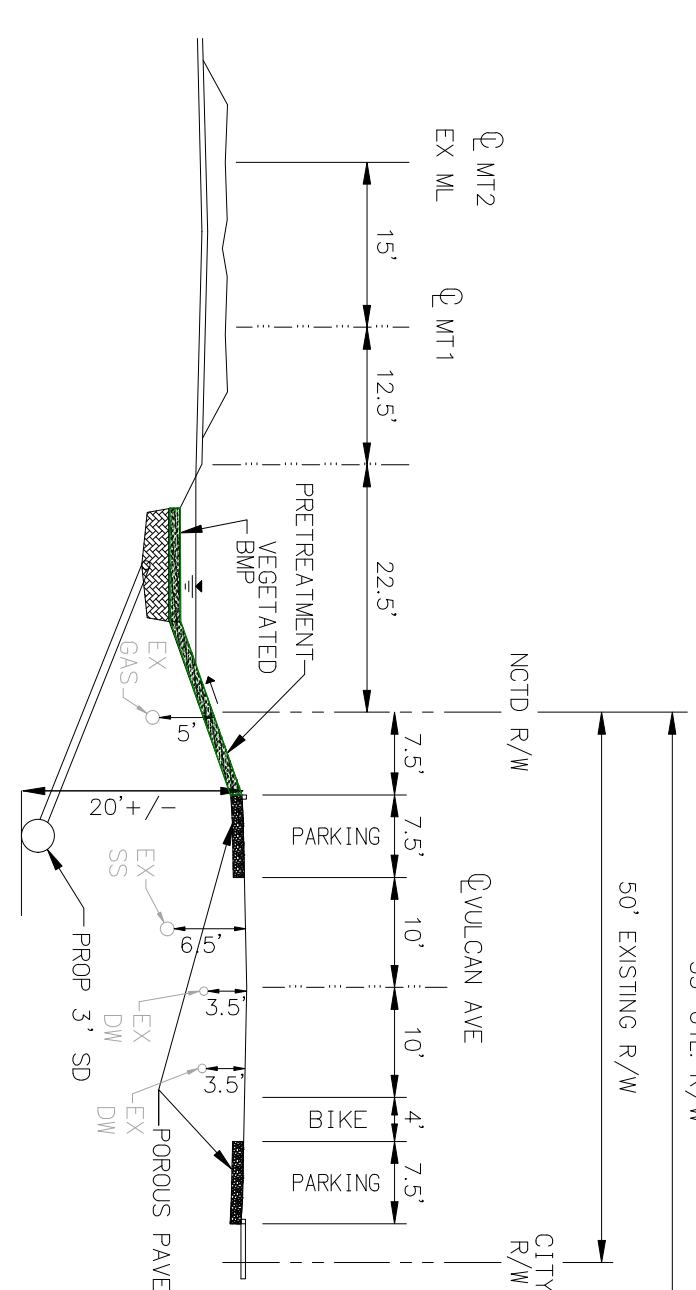
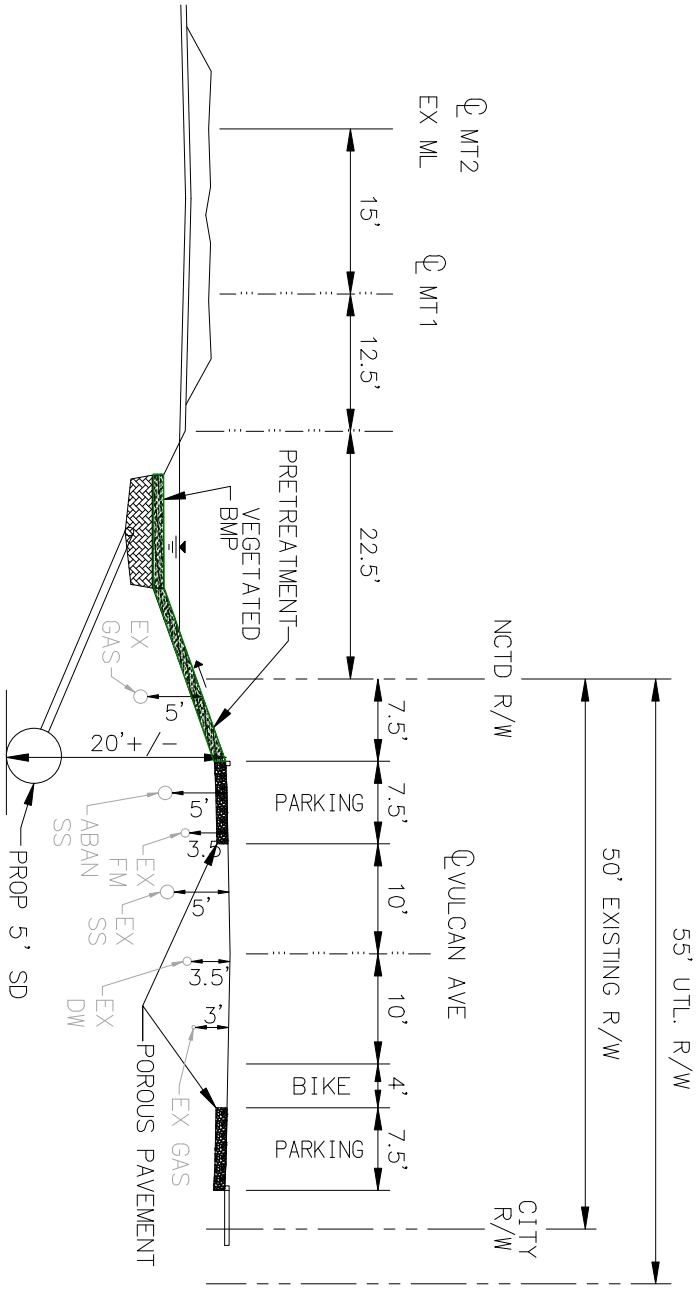
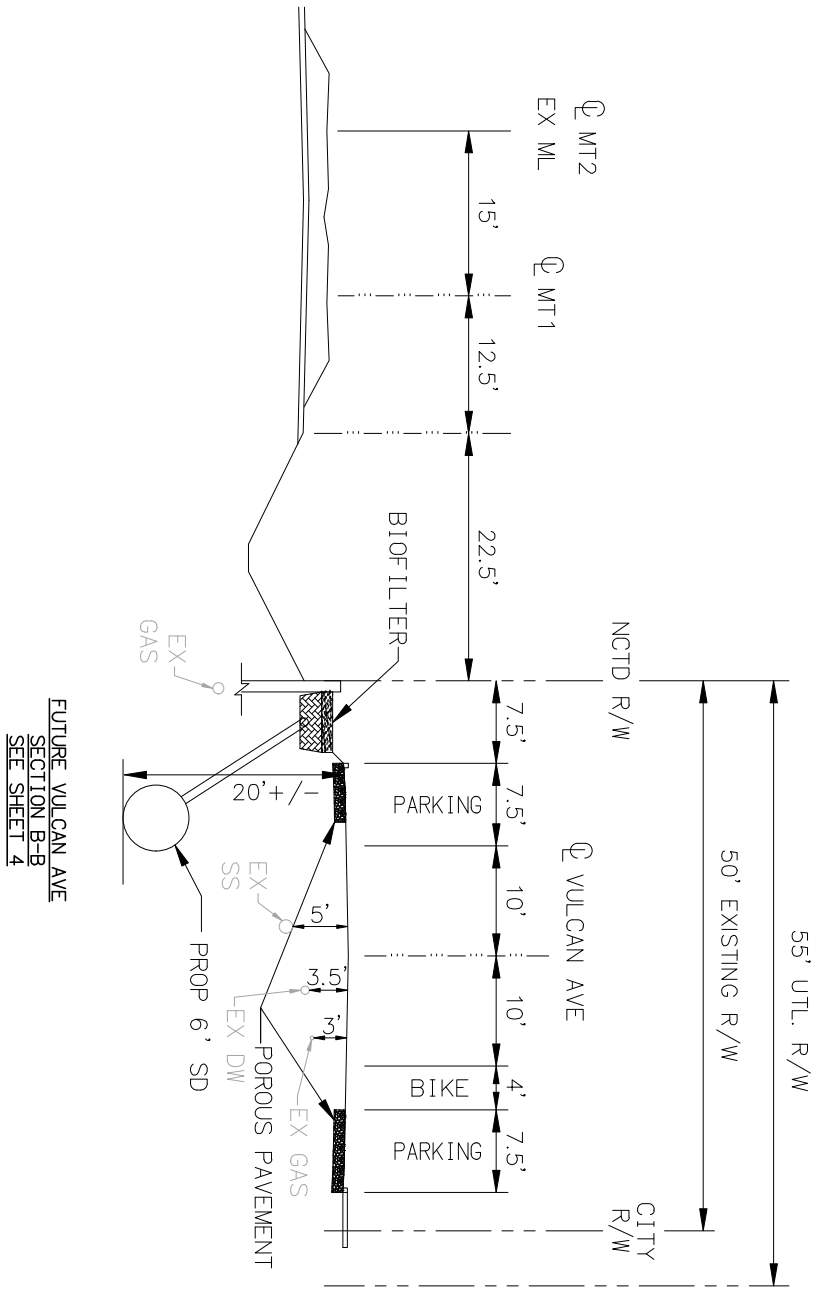
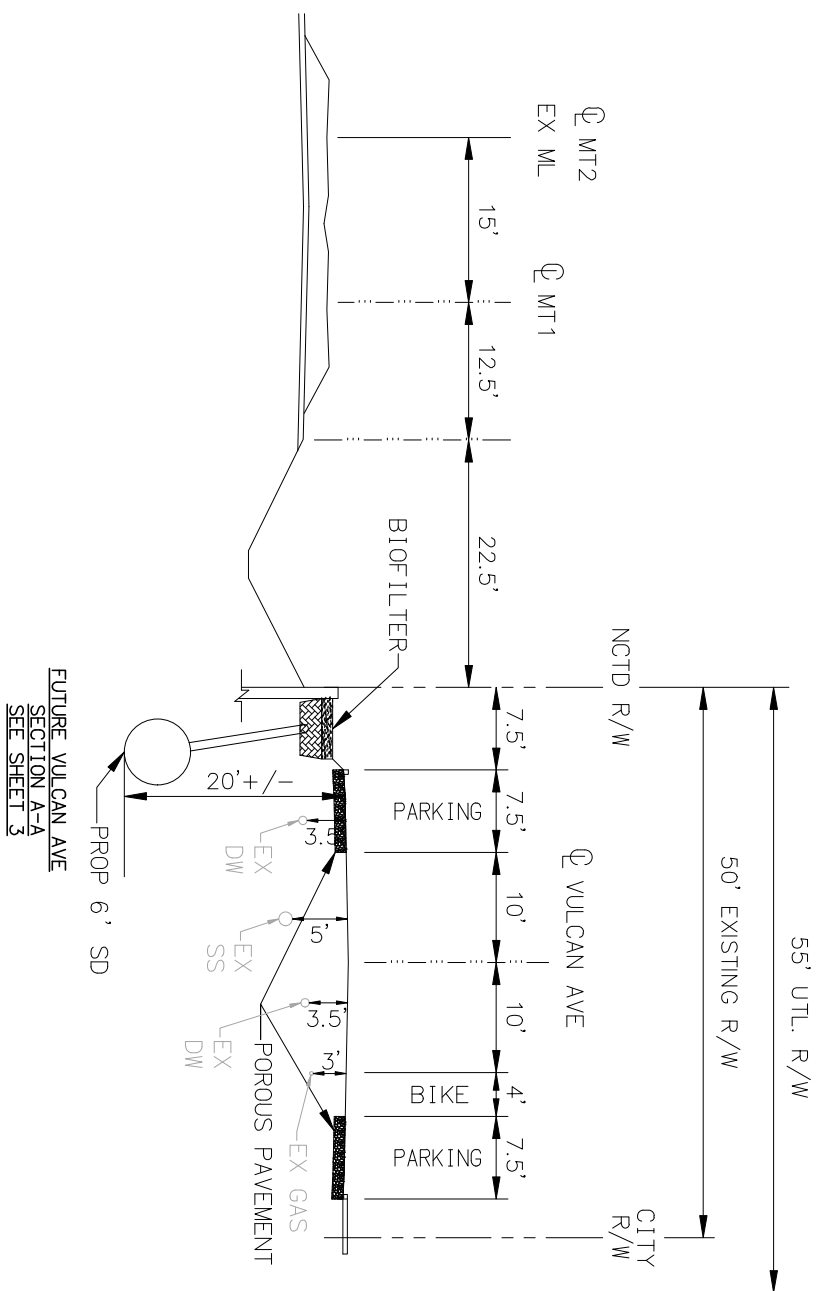


5050 Avenida Encinas  
Suite 260  
Carlsbad, CA 92008  
Phone: (760) 476-9193  
MBAKERINTL.COM

Michael Baker  
INTERNATIONAL

**DRAFT**  
**VULCAN AVENUE STORM DRAIN**  
**TITLE SHEET**  
**SHEET 1 OF 7**





NOTE:  
EXISTING UTILITIES ARE BASED ON GIS AND  
WILL NEED TO BE LOCATED MORE ACCURATELY  
FOR FINAL DESIGN. ALL UTILITIES ARE  
ASSUMED TYPICAL DEPTHS.

FUTURE VULCAN AVE  
SECTION D-D  
SEE SHEET 6

DRAFT

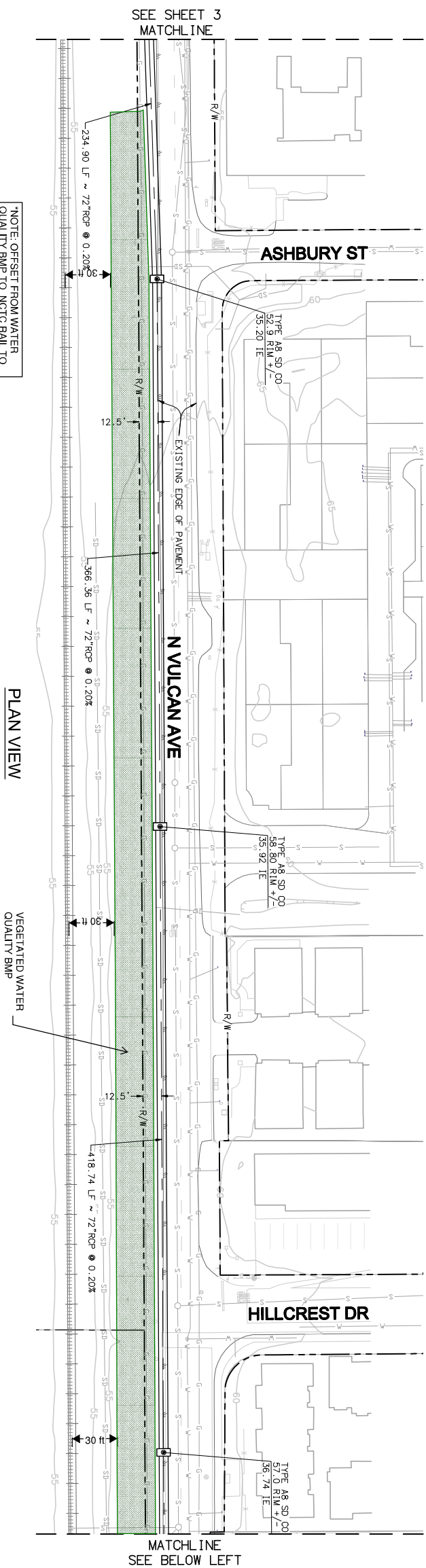
Michael Baker  
INTERNATIONAL

5050 Avenida Encinas  
Suite 260  
Carlsbad, CA 92008  
Phone: (760) 476-9193  
mbakerintl.com

VULCAN AVENUE STORM DRAIN  
TYPICAL CROSS SECTIONS &  
DETAILS  
SHEET 2 OF 7



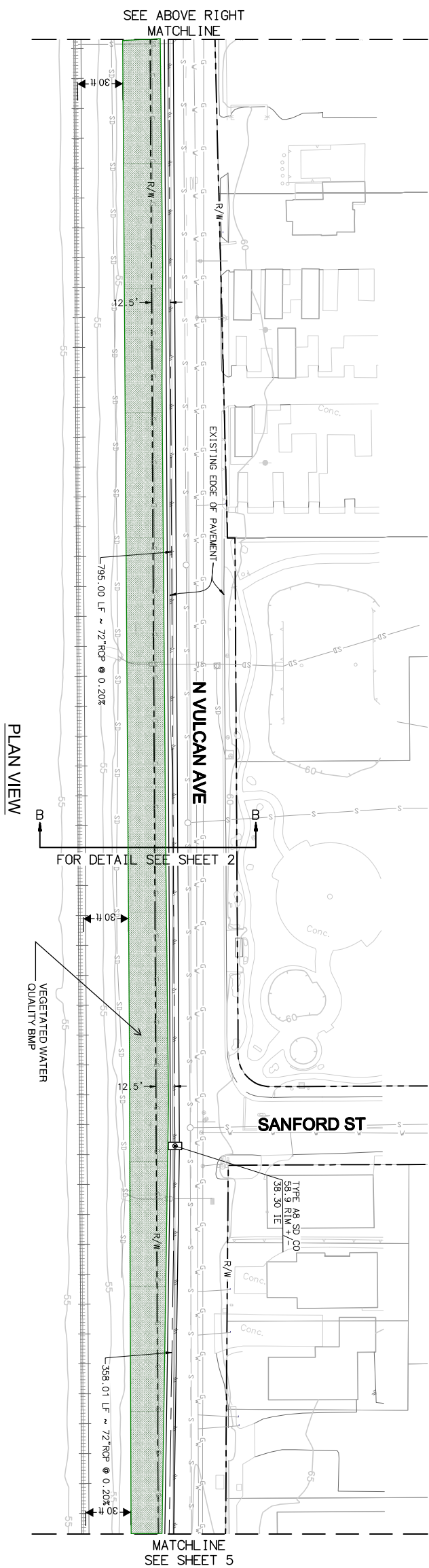




## PLAN VIEW

## VEGETATED WATER QUALITY BMP

\*NOTE: OFFSET FROM WATER QUALITY BMP TO NCTC RAIL TO BE DETERMINED DURING FINAL DESIGN

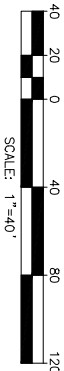


## PLAN VIEW

FOR DETAIL SEE SHEET 2

VEGETATED WATER  
- QUALITY BMP

NOTE:  
EXISTING UTILITIES ARE BASED ON GIS AND  
WILL NEED TO BE LOCATED MORE ACCURATELY  
FOR FINAL DESIGN



SCALE: 1"=40'

DRAFT

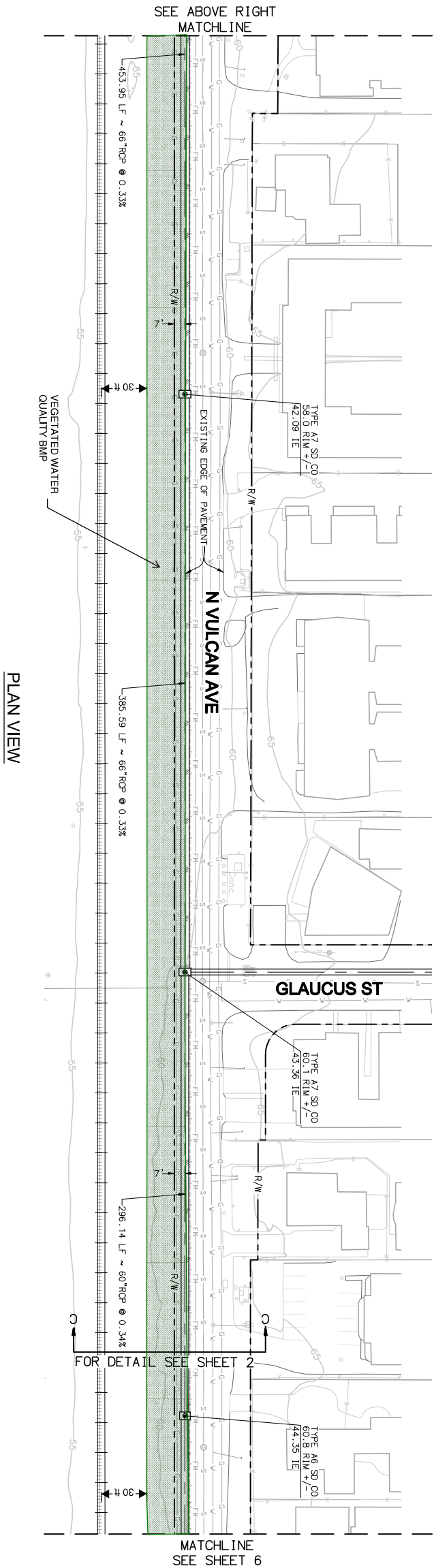
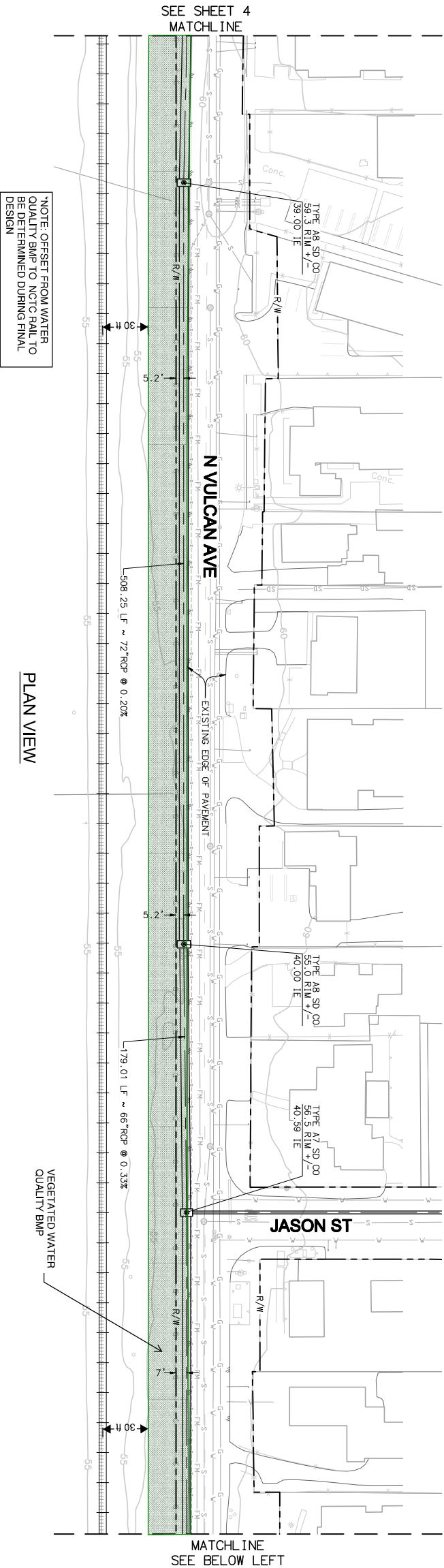
# VULCAN AVENUE STORM DRAIN

# STORM DRAIN PLAN

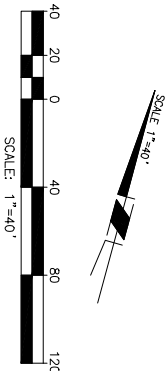
**SHEET 4 OF 7**

**Michael Baker**  
**INTERNATIONAL**

5050 Avenida Encinas  
Suite 260  
Carlsbad, CA 92008  
Phone: (760) 476-9193  
MBAKERINTL.COM



NOTE:  
EXISTING UTILITIES ARE BASED ON GIS AND  
WILL NEED TO BE LOCATED MORE ACCURATELY  
FOR FINAL DESIGN



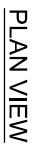
**Michael Baker**  
**INTERNATIONAL**

5050 Avenida Encinas  
Suite 260  
Carlsbad, CA 92008  
Phone: (760) 476-9193  
MBAKERINTL.COM

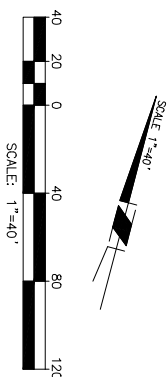
**VULCAN AVENUE STORM DRAIN**  
**STORM DRAIN PLAN**  
**SHEET 5 OF 7**



### PLAN VIEW



NOTE:  
EXISTING UTILITIES ARE BASED ON GIS AND  
WILL NEED TO BE LOCATED MORE ACCURATELY  
FOR FINAL DESIGN



DRAFT

**VULCAN AVENUE STORM DRAIN**

# Michael Baker

# INTERNATIONAL

5050 Avenida Encinas  
Suite 260  
Carlsbad, CA 92008  
Phone: (760) 476-9193  
MBAKERINTL.COM



## A.2 South Leucadia Storm Drain System Concept Plans (Main Line)

# LEUCADIA WATERSHED FEASIBILITY STUDY

## LEUCADIA SOUTH STORM DRAIN CONCEPT PLAN

### ABBREVIATIONS

| AB   | AGGREGATE BASE           | PCC  | POINT OF CONTINUOUS CURVE   |
|------|--------------------------|------|-----------------------------|
| AC   | ASPHALT CONCRETE         | PP   | POWER POLE                  |
| APN  | ASSessor'S PARCEL NUMBER | PR   | PROPOSED                    |
| BC   | BEGIN CURVE              | PRC  | POINT OF REVERSE CURVE      |
| BR   | BEGIN CURB RETURN        | PRV  | PRESSURE REDUCING VALVE     |
| BVC  | BEGIN VERTICAL CURVE     | PWT  | PAVEMENT                    |
| C&G  | CURB & GUTTER            | RET  | RETAINING                   |
| CO   | CLEAN OUT                | RIM  | RIM ELEVATION               |
| CONC | CONCRETE                 | SCO  | SEWER CLEANOUT              |
| EC   | END CURVE                | SD   | STORM DRAIN                 |
| EOR  | EDGE OF ROAD RETURN      | SD&E | SAN DIEGO GAS & ELECTRIC    |
| ED   | EDGE OF PAVEMENT         | SD&S | SAN DIEGO SEWAGE            |
| END  | END POINT                | SD&W | STANDARD SIDEWALK           |
| EX   | EXISTING                 | SDWD | SAN DIEGO TO WATER DISTRICT |
| FG   | FINISH GRADE             | SMH  | SEWER MANHOLE               |
| FL   | FLOWLINE                 | STD  | STANDARD                    |
| FS   | FINISH SURFACE           | SV   | SEWER VALVE                 |
| GV   | GAS VALVE                | SWK  | SIDEWALK                    |
| HP   | HIGH POINT               | TB   | TOP OF BERM                 |
| IE   | INVERT ELEVATION         | TC   | TOP OF CURB                 |
| LF   | LINEAR FEET              | TS   | TRAFFIC SIGNAL              |
| MB   | MANHOLE                  | WMS  | WATER METER STANDARDS       |
| MBW  | MANHOLE                  | WM   | WATER METER                 |
| PCC  | PORTLAND CEMENT CONCRETE | WV   | WATER VALVE                 |

### SHEET INDEX

| SHEET | DESCRIPTION            |
|-------|------------------------|
| 1     | TITLE SHEET            |
| 2     | TYPICAL CROSS SECTIONS |
| 3-5   | STORM DRAIN PLANS      |

### BASIS OF COORDINATES

THE COORDINATES AND BEARINGS SHOWN HEREON ARE BASED UPON THE CALIFORNIA COORDINATE SYSTEM OF 1983. (CORS83), ZONE 6. (GPRS EPOCH 2009.00). SAID COORDINATES AND BEARINGS ARE BASED LOCALLY UPON GLOBAL POSITIONING SYSTEM TIES TO THE FOLLOWING CONTINUOUS OPERATING REFERENCE STATIONS (CORS) AS PUBLISHED BY THE NATIONAL GEODETIC SURVEY (NGS). PUBLISHED POSITIONS FOR SAID STATIONS ARE BASED UPON THE NORTH AMERICAN DATUM OF 1983. (NAD83)

| STATION | NORTHING (ft.) | EASTING (ft.) |
|---------|----------------|---------------|
| P478    | 2030380.574    | 6310453.304   |
| DSME    | 1958366.104    | 6255349.651   |

THE BASIS OF BEARINGS IS THE CALCULATED BEARING BETWEEN SAID CORNS DSME & P478. I.E. N37°25'20"W  
DISTANCES SHOWN HEREON ARE GROUND AND IN TERMS OF THE U.S. SURVEY FOOT.  
CONTROL POINT 100: GRID DISTANCE = GROUND DISTANCE X COMBINED SCALE FACTOR (0.99996699)

### SOURCE OF TOPOGRAPHY

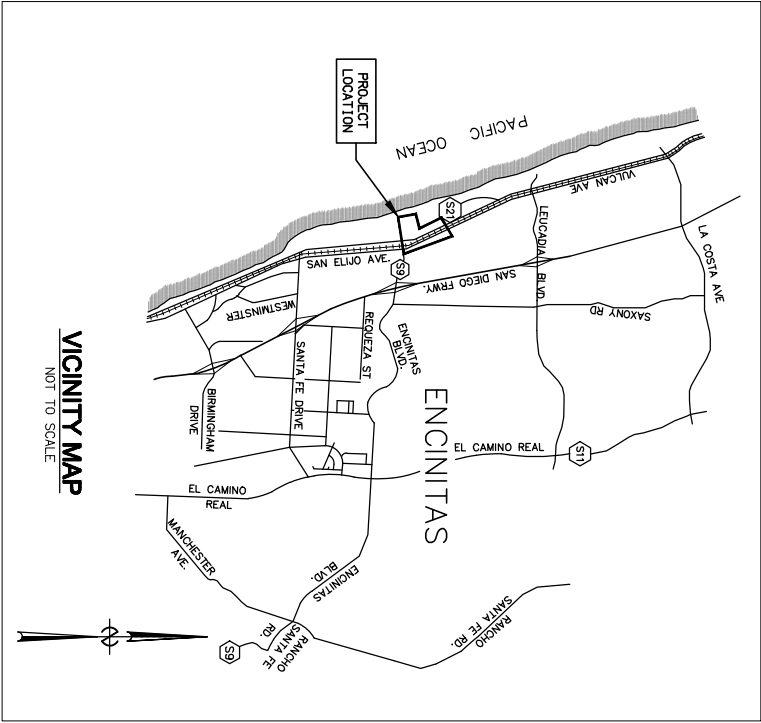
TOPOGRAPHIC INFORMATION FOR THIS SURVEY IS PER MOBILE LIDAR SCANNING PERFORMED BY MICHAEL BAKER INTERNATIONAL IN NOVEMBER OF 2019. THE INFORMATION IS BASED UPON CONVENTIONAL TOTAL STATION SURVEY INFORMATION GATHERED BY MICHAEL BAKER INTERNATIONAL FROM OCTOBER OF 2018 THROUGH JULY OF 2019.

### BENCHMARK

THE BASIS OF ELEVATIONS FOR THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) PER RECORD OF SURVEY 18416 CITY OF ENCINITAS SURVEY CONTROL. BENCHMARK DESIGNATION: POINT NUMBER 1004/ENC-4  
ELEVATION: 67.639 (NAVD88)

### VICINITY MAP

NOT TO SCALE

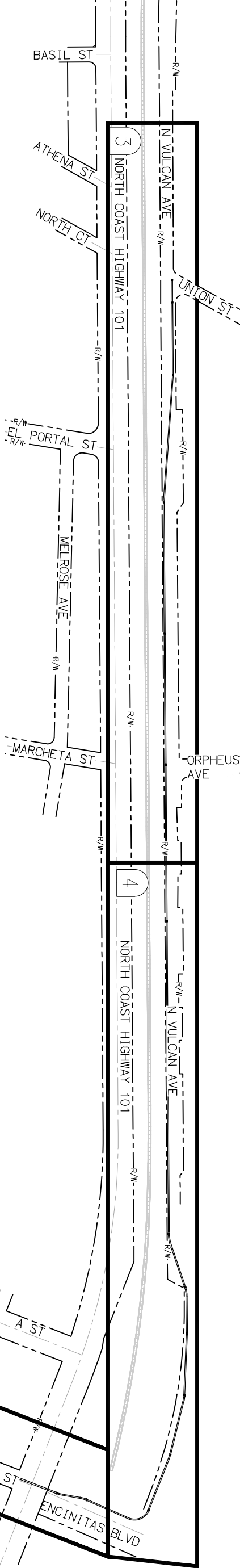


### PROJECT LOCATION

VULCAN AVENUE - UNION STREET TO LA COSTA AVE  
ENCINITAS, CALIFORNIA 92024

### LEGEND

| ITEM                          | STANDARD DWG | SYMBOL   |
|-------------------------------|--------------|----------|
| EXISTING MEDIAN CURB          |              | =====    |
| ROP STORM DRAIN               |              | =====    |
| CURB INLET - TYPE A           |              | SD&S D-1 |
| CURB INLET - TYPE B           |              | SD&S D-2 |
| STORM DRAIN CLEANOUT - TYPE A |              | SD&S D-9 |
| PROPOSED CONTOUR              |              | 212      |
| EXISTING CONTOUR              |              | (212)    |
| DAYLIGHT LINE                 |              | 212      |
| 2: 1 PROPOSED SLOPE           |              | 2:1      |
| NODD LIMIT LINE               |              | ----     |
| EXISTING PROPERTY LINE        |              | ----     |
| STREET CENTERLINE             |              | ----     |
| EXISTING RIGHT OF WAY LINE    |              | ----     |
| EXISTING CONCRETE             |              | ----     |
| EXISTING EDGE OF PAVEMENT     |              | ----     |
| EXISTING WALL                 |              | ----     |
| EXISTING FENCE                |              | ----     |
| EXISTING WATER VALVE          |              | ⊕        |
| EXISTING FIRE HYDRANT         |              | ⊕        |
| EXISTING WATER METER          |              | ⊕        |
| EXISTING SEWER MANHOLE        |              | ⊕        |
| EXISTING SIGN                 |              | ⊕        |
| EXISTING STREET LIGHT         |              | ⊕        |
| EXISTING STORM DRAIN          |              | ----     |
| EXISTING SEWER LINE           |              | ----     |
| EXISTING WATER LINE           |              | ----     |
| EXISTING GAS LINE             |              | ----     |



### INDEX MAP LEGEND

|    |                          |
|----|--------------------------|
| XX | STORM DRAIN SHEET NUMBER |
|----|--------------------------|

Michael Baker

INTERNATIONAL

5055 Avenida Encinitas

Suite 260

Carlsbad, CA 92008

Phone: (760) 476-9193

mbakerintl.com

DRAFT

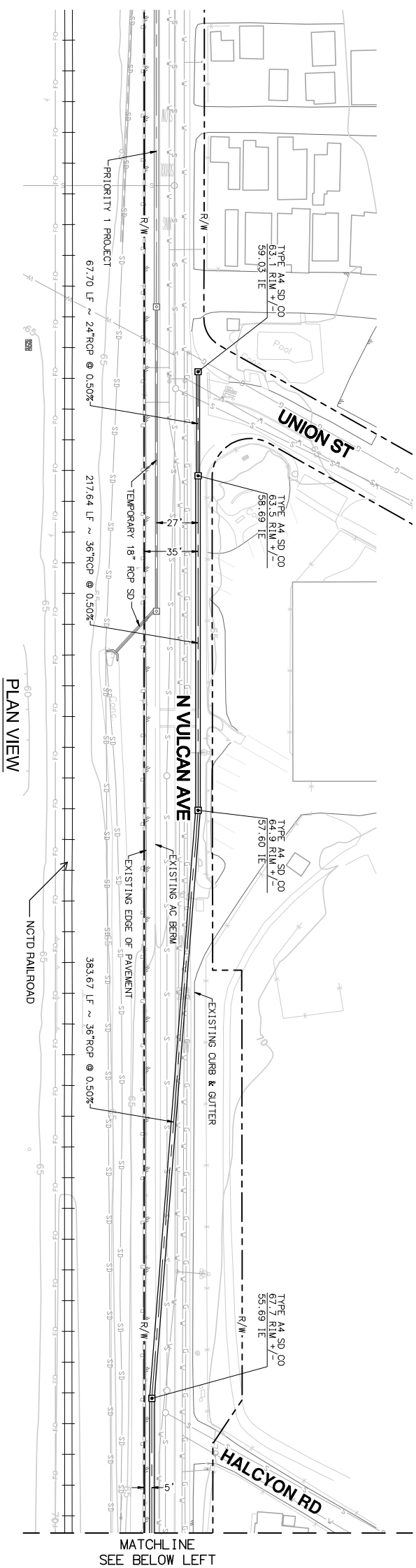
LEUCADIA SOUTH STORM DRAIN

TITLE SHEET

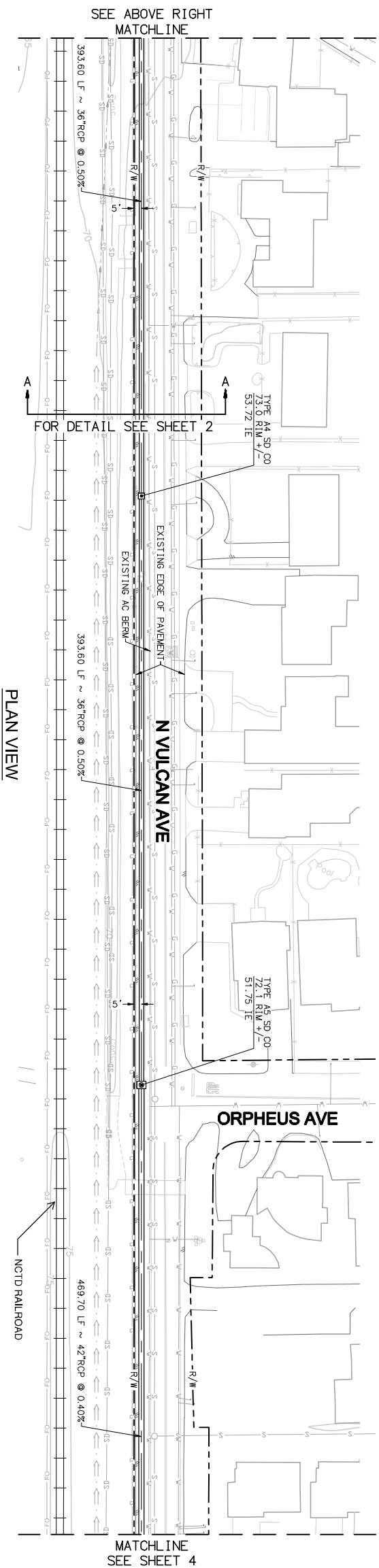
SHEET 1 OF 5



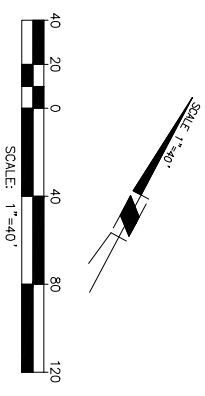


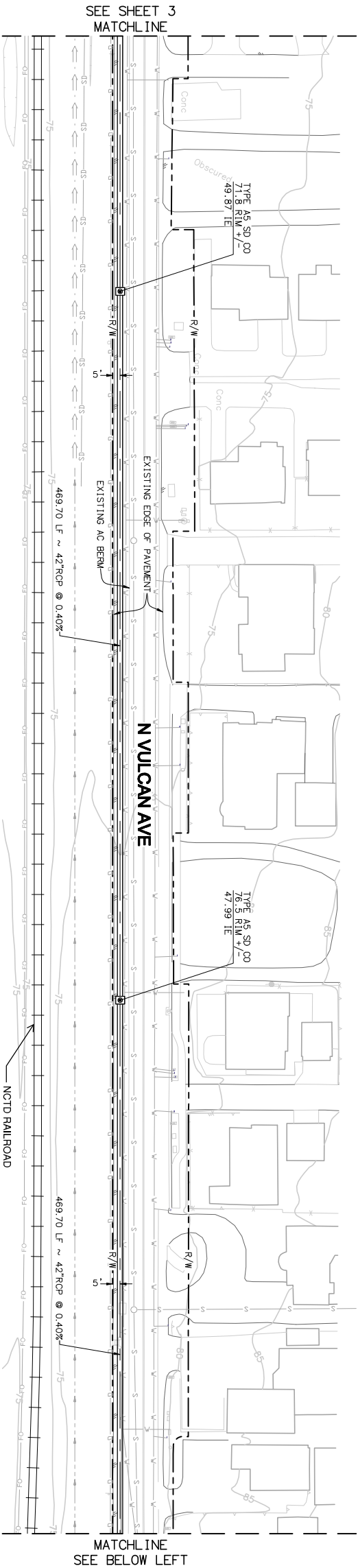


\*NOTE: AREA ALONG SOUTHERN SHOULDER OF VULCAN AVENUE IS CURRENTLY UNDER CONSTRUCTION. NEW SURFACE TO BE PREPARED PER FINAL DESIGN.

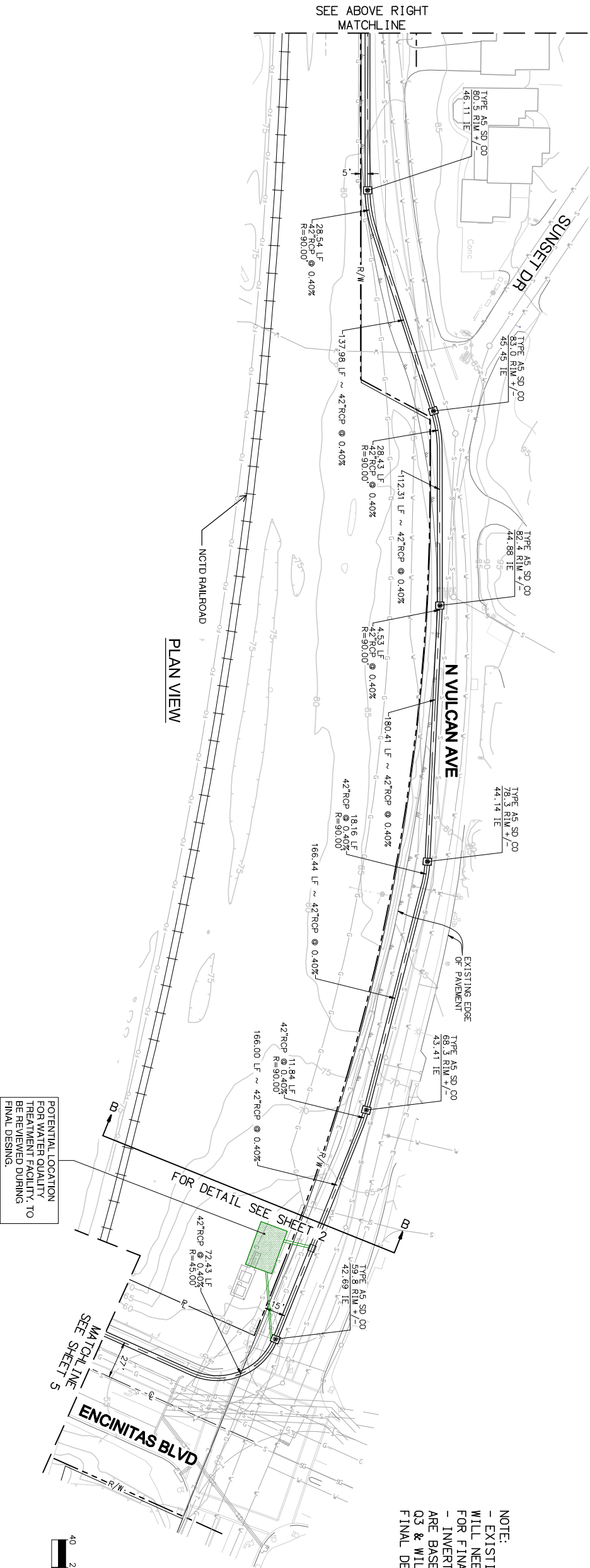


NOTE:  
- EXISTING UTILITIES ARE BASED ON GIS AND  
WILL NEED TO BE LOCATED MORE ACCURATELY  
FOR FINAL DESIGN  
- INVERT ELEVATIONS SHOWN ON THESE PLANS  
ARE BASED ON THE XPSMM DATA PROVIDED BY  
Q3 & WILL NEED TO BE EVALUATED DURING  
FINAL DESIGN.



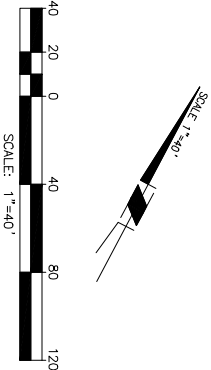


PLAN VIEW



PLAN VIEW

NOTE:  
- EXISTING UTILITIES ARE BASED ON GIS AND WILL NEED TO BE LOCATED MORE ACCURATELY FOR FINAL DESIGN  
- INVERT ELEVATIONS SHOWN ON THESE PLANS ARE BASED ON THE XPSMM DATA PROVIDED BY 03 & WILL NEED TO BE EVALUATED DURING FINAL DESIGN.



POTENTIAL LOCATION  
FOR WATER QUALITY  
TREATMENT FACILITY,  
TO  
BE REVIEWED DURING  
FINAL DESIGN.

DRAFT

LEUCADIA SOUTH STORM DRAIN

Michael Baker

INTERNATIONAL

5050 Avenida Encinas  
Suite 260  
Carlsbad, CA 92008  
Phone: (760) 476-9193  
MBAKERINTL.COM

STORM DRAIN PLAN

SHEET 4 OF 5





## **APPENDIX B**

### **Existing Conditions Calculations**

1. NOAA 14 Rainfall Data
2. Loss Rate Calculations (Land Use Based)
3. Validation Analysis Data
  - a. Rainfall Records
  - b. Observation Data (Relevant Photos)
4. XPStorm (Digital Files)
  - a. 100-Year/24hr
  - b. 50-Year/24hr
  - c. 10-Year/24hr
  - d. 5-Year/24hr
  - e. December 12, 2014

## B.1 NOAA 14 Rainfall Data for Leucadia



**NOAA Atlas 14, Volume 6, Version 2**  
**Location name: Encinitas, California, USA\***  
**Latitude: 33.0628°, Longitude: -117.2891°**  
**Elevation: 176.73 ft\*\***

\* source: ESRI Maps  
 \*\* source: USGS



**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

[PF\\_tabular](#) | [PF\\_graphical](#) | [Maps\\_&\\_aerials](#)

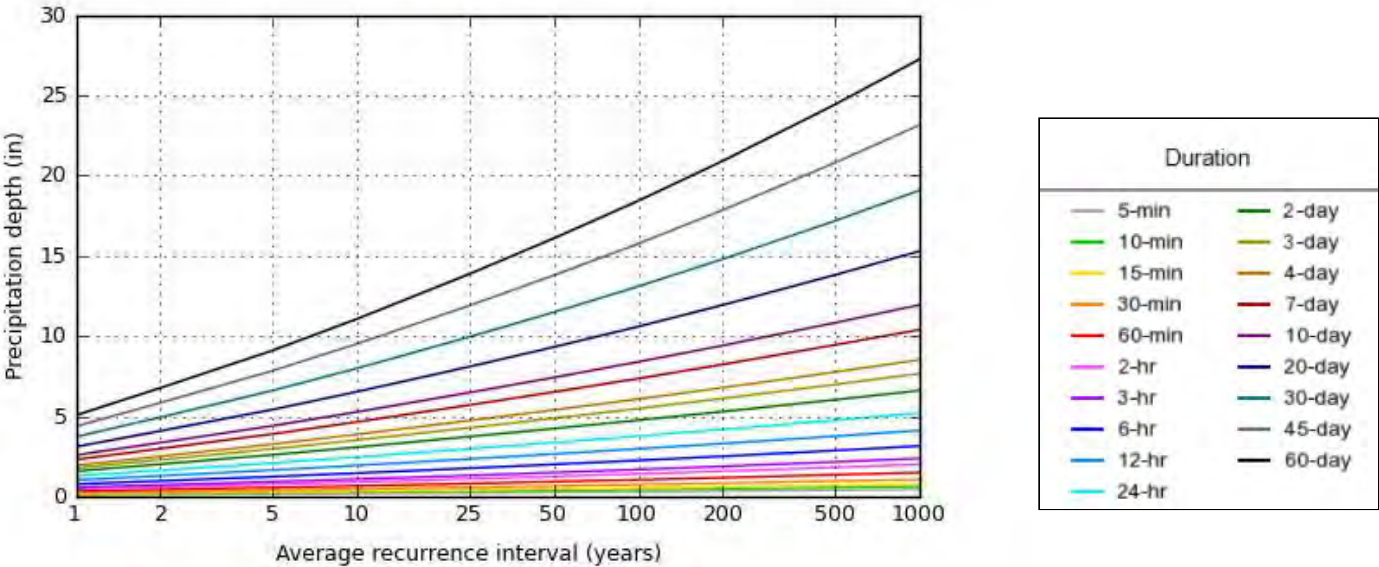
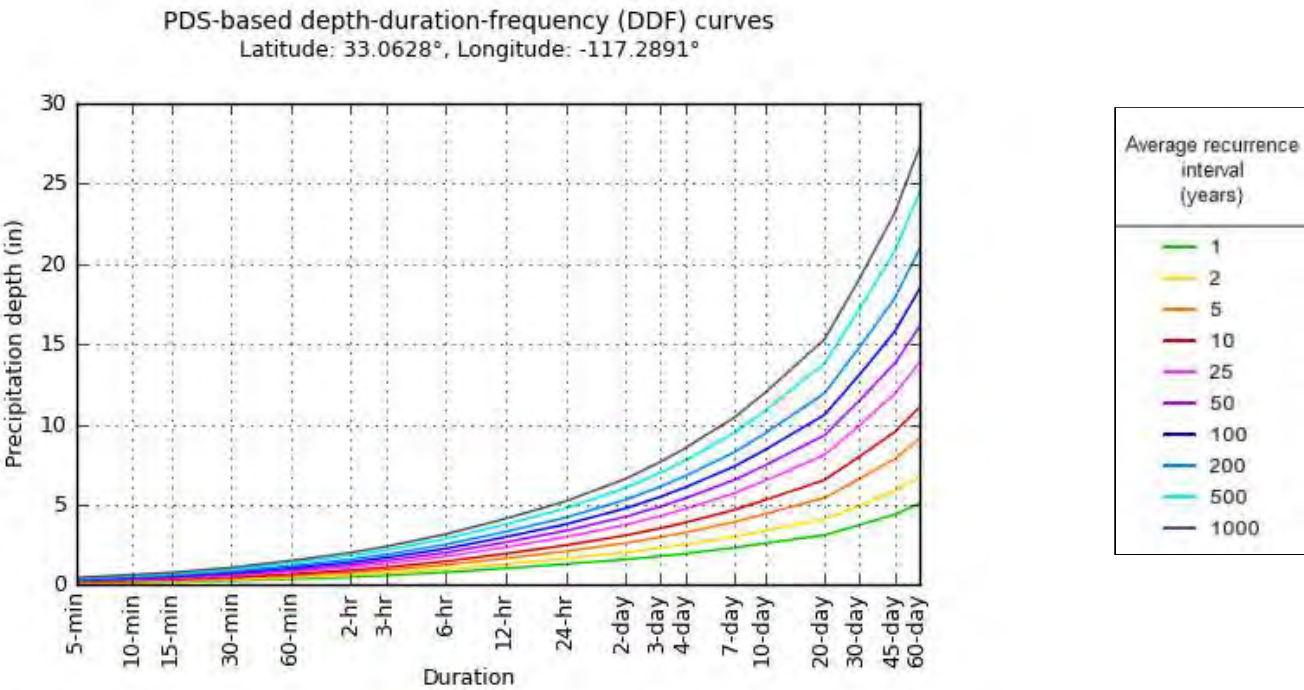
**PF tabular**

| <b>PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup></b> |  |                               |                               |                               |                               |                               |                               |                               |                               |                               |
|--|--|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| <b>Duration</b>  | <b>Average recurrence interval (years)</b> |                               |                               |                               |                               |                               |                               |                               |                               |                               |
|  | <b>1</b>                                   | <b>2</b>                      | <b>5</b>                      | <b>10</b>                     | <b>25</b>                     | <b>50</b>                     | <b>100</b>                    | <b>200</b>                    | <b>500</b>                    | <b>1000</b>                   |
| <b>5-min</b>   | <b>0.103</b><br>(0.087-0.124)              | <b>0.130</b><br>(0.109-0.156) | <b>0.165</b><br>(0.138-0.199) | <b>0.195</b><br>(0.162-0.238) | <b>0.238</b><br>(0.191-0.300) | <b>0.272</b><br>(0.213-0.350) | <b>0.307</b><br>(0.234-0.407) | <b>0.345</b><br>(0.255-0.470) | <b>0.398</b><br>(0.282-0.567) | <b>0.440</b><br>(0.301-0.651) |
| <b>10-min</b>  | <b>0.148</b><br>(0.124-0.178)              | <b>0.186</b><br>(0.156-0.223) | <b>0.237</b><br>(0.198-0.286) | <b>0.280</b><br>(0.233-0.341) | <b>0.341</b><br>(0.273-0.430) | <b>0.389</b><br>(0.305-0.502) | <b>0.440</b><br>(0.336-0.583) | <b>0.494</b><br>(0.366-0.674) | <b>0.570</b><br>(0.404-0.813) | <b>0.631</b><br>(0.431-0.933) |
| <b>15-min</b>  | <b>0.179</b><br>(0.150-0.215)              | <b>0.225</b><br>(0.189-0.270) | <b>0.287</b><br>(0.240-0.346) | <b>0.339</b><br>(0.281-0.412) | <b>0.412</b><br>(0.330-0.520) | <b>0.471</b><br>(0.369-0.607) | <b>0.532</b><br>(0.406-0.705) | <b>0.598</b><br>(0.443-0.815) | <b>0.689</b><br>(0.488-0.983) | <b>0.763</b><br>(0.521-1.13)  |
| <b>30-min</b>  | <b>0.251</b><br>(0.211-0.302)              | <b>0.315</b><br>(0.265-0.379) | <b>0.402</b><br>(0.337-0.485) | <b>0.476</b><br>(0.395-0.579) | <b>0.579</b><br>(0.464-0.730) | <b>0.661</b><br>(0.518-0.853) | <b>0.747</b><br>(0.570-0.990) | <b>0.839</b><br>(0.621-1.14)  | <b>0.968</b><br>(0.686-1.38)  | <b>1.07</b><br>(0.732-1.58)   |
| <b>60-min</b>  | <b>0.353</b><br>(0.297-0.424)              | <b>0.443</b><br>(0.372-0.533) | <b>0.565</b><br>(0.473-0.682) | <b>0.668</b><br>(0.555-0.813) | <b>0.813</b><br>(0.651-1.02)  | <b>0.929</b><br>(0.727-1.20)  | <b>1.05</b><br>(0.801-1.39)   | <b>1.18</b><br>(0.873-1.61)   | <b>1.36</b><br>(0.963-1.94)   | <b>1.51</b><br>(1.03-2.23)    |
| <b>2-hr</b>  | <b>0.486</b><br>(0.409-0.583)              | <b>0.608</b><br>(0.511-0.731) | <b>0.773</b><br>(0.647-0.932) | <b>0.911</b><br>(0.756-1.11)  | <b>1.10</b><br>(0.884-1.39)   | <b>1.26</b><br>(0.984-1.62)   | <b>1.42</b><br>(1.08-1.87)    | <b>1.58</b><br>(1.17-2.16)    | <b>1.82</b><br>(1.29-2.59)    | <b>2.01</b><br>(1.37-2.97)    |
| <b>3-hr</b>  | <b>0.581</b><br>(0.489-0.698)              | <b>0.728</b><br>(0.611-0.875) | <b>0.924</b><br>(0.774-1.12)  | <b>1.09</b><br>(0.904-1.33)   | <b>1.32</b><br>(1.06-1.66)    | <b>1.50</b><br>(1.17-1.93)    | <b>1.69</b><br>(1.29-2.23)    | <b>1.88</b><br>(1.40-2.57)    | <b>2.16</b><br>(1.53-3.08)    | <b>2.38</b><br>(1.63-3.52)    |
| <b>6-hr</b>  | <b>0.778</b><br>(0.654-0.934)              | <b>0.977</b><br>(0.820-1.18)  | <b>1.24</b><br>(1.04-1.50)    | <b>1.46</b><br>(1.21-1.78)    | <b>1.77</b><br>(1.42-2.23)    | <b>2.01</b><br>(1.57-2.59)    | <b>2.25</b><br>(1.72-2.98)    | <b>2.51</b><br>(1.86-3.43)    | <b>2.87</b><br>(2.03-4.09)    | <b>3.15</b><br>(2.15-4.66)    |
| <b>12-hr</b>   | <b>1.03</b><br>(0.864-1.24)                | <b>1.30</b><br>(1.09-1.56)    | <b>1.65</b><br>(1.38-1.99)    | <b>1.94</b><br>(1.61-2.36)    | <b>2.34</b><br>(1.88-2.95)    | <b>2.65</b><br>(2.08-3.42)    | <b>2.97</b><br>(2.27-3.94)    | <b>3.31</b><br>(2.45-4.51)    | <b>3.76</b><br>(2.67-5.37)    | <b>4.12</b><br>(2.82-6.10)    |
| <b>24-hr</b>   | <b>1.29</b><br>(1.14-1.49)                 | <b>1.64</b><br>(1.44-1.90)    | <b>2.09</b><br>(1.84-2.43)    | <b>2.46</b><br>(2.15-2.88)    | <b>2.97</b><br>(2.51-3.59)    | <b>3.37</b><br>(2.79-4.15)    | <b>3.77</b><br>(3.05-4.75)    | <b>4.19</b><br>(3.30-5.42)    | <b>4.76</b><br>(3.61-6.40)    | <b>5.20</b><br>(3.82-7.23)    |
| <b>2-day</b>   | <b>1.58</b><br>(1.39-1.83)                 | <b>2.02</b><br>(1.78-2.34)    | <b>2.60</b><br>(2.29-3.02)    | <b>3.08</b><br>(2.68-3.61)    | <b>3.73</b><br>(3.15-4.51)    | <b>4.24</b><br>(3.51-5.22)    | <b>4.76</b><br>(3.85-6.00)    | <b>5.30</b><br>(4.18-6.86)    | <b>6.03</b><br>(4.57-8.12)    | <b>6.61</b><br>(4.85-9.19)    |
| <b>3-day</b>   | <b>1.78</b><br>(1.57-2.06)                 | <b>2.29</b><br>(2.02-2.66)    | <b>2.97</b><br>(2.60-3.45)    | <b>3.52</b><br>(3.07-4.12)    | <b>4.28</b><br>(3.62-5.18)    | <b>4.88</b><br>(4.04-6.01)    | <b>5.49</b><br>(4.44-6.92)    | <b>6.12</b><br>(4.82-7.92)    | <b>6.98</b><br>(5.30-9.40)    | <b>7.66</b><br>(5.63-10.7)    |
| <b>4-day</b>   | <b>1.94</b><br>(1.71-2.25)                 | <b>2.51</b><br>(2.21-2.91)    | <b>3.26</b><br>(2.86-3.79)    | <b>3.88</b><br>(3.38-4.54)    | <b>4.73</b><br>(4.00-5.72)    | <b>5.40</b><br>(4.47-6.65)    | <b>6.08</b><br>(4.92-7.66)    | <b>6.79</b><br>(5.35-8.78)    | <b>7.76</b><br>(5.89-10.4)    | <b>8.53</b><br>(6.26-11.9)    |
| <b>7-day</b>   | <b>2.30</b><br>(2.03-2.67)                 | <b>2.99</b><br>(2.63-3.46)    | <b>3.90</b><br>(3.42-4.53)    | <b>4.66</b><br>(4.06-5.45)    | <b>5.70</b><br>(4.81-6.89)    | <b>6.52</b><br>(5.40-8.03)    | <b>7.36</b><br>(5.96-9.28)    | <b>8.24</b><br>(6.50-10.7)    | <b>9.45</b><br>(7.17-12.7)    | <b>10.4</b><br>(7.64-14.5)    |
| <b>10-day</b>  | <b>2.59</b><br>(2.28-2.99)                 | <b>3.36</b><br>(2.96-3.90)    | <b>4.41</b><br>(3.87-5.12)    | <b>5.28</b><br>(4.60-6.18)    | <b>6.48</b><br>(5.47-7.83)    | <b>7.42</b><br>(6.15-9.14)    | <b>8.40</b><br>(6.80-10.6)    | <b>9.42</b><br>(7.43-12.2)    | <b>10.8</b><br>(8.21-14.6)    | <b>11.9</b><br>(8.77-16.6)    |
| <b>20-day</b>  | <b>3.10</b><br>(2.73-3.59)                 | <b>4.09</b><br>(3.60-4.74)    | <b>5.42</b><br>(4.76-6.30)    | <b>6.54</b><br>(5.70-7.65)    | <b>8.09</b><br>(6.83-9.77)    | <b>9.32</b><br>(7.72-11.5)    | <b>10.6</b><br>(8.58-13.4)    | <b>11.9</b><br>(9.42-15.5)    | <b>13.8</b><br>(10.5-18.6)    | <b>15.3</b><br>(11.2-21.3)    |
| <b>30-day</b>  | <b>3.72</b><br>(3.28-4.31)                 | <b>4.95</b><br>(4.36-5.73)    | <b>6.60</b><br>(5.80-7.67)    | <b>7.99</b><br>(6.96-9.36)    | <b>9.94</b><br>(8.40-12.0)    | <b>11.5</b><br>(9.52-14.2)    | <b>13.1</b><br>(10.6-16.5)    | <b>14.8</b><br>(11.7-19.2)    | <b>17.2</b><br>(13.0-23.1)    | <b>19.1</b><br>(14.0-26.5)    |
| <b>45-day</b>  | <b>4.38</b><br>(3.86-5.07)                 | <b>5.84</b><br>(5.15-6.77)    | <b>7.84</b><br>(6.89-9.11)    | <b>9.52</b><br>(8.30-11.2)    | <b>11.9</b><br>(10.0-14.4)    | <b>13.8</b><br>(11.4-17.0)    | <b>15.8</b><br>(12.8-19.9)    | <b>17.9</b><br>(14.1-23.1)    | <b>20.8</b><br>(15.8-28.0)    | <b>23.2</b><br>(17.0-32.2)    |
| <b>60-day</b>  | <b>5.07</b><br>(4.47-5.87)                 | <b>6.77</b><br>(5.96-7.85)    | <b>9.10</b><br>(7.99-10.6)    | <b>11.1</b><br>(9.65-13.0)    | <b>13.9</b><br>(11.7-16.7)    | <b>16.1</b><br>(13.3-19.8)    | <b>18.4</b><br>(14.9-23.2)    | <b>20.9</b><br>(16.5-27.1)    | <b>24.4</b><br>(18.5-32.9)    | <b>27.3</b><br>(20.0-37.9)    |

<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).  
 Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.  
 Please refer to NOAA Atlas 14 document for more information.

[Back to Top](#)

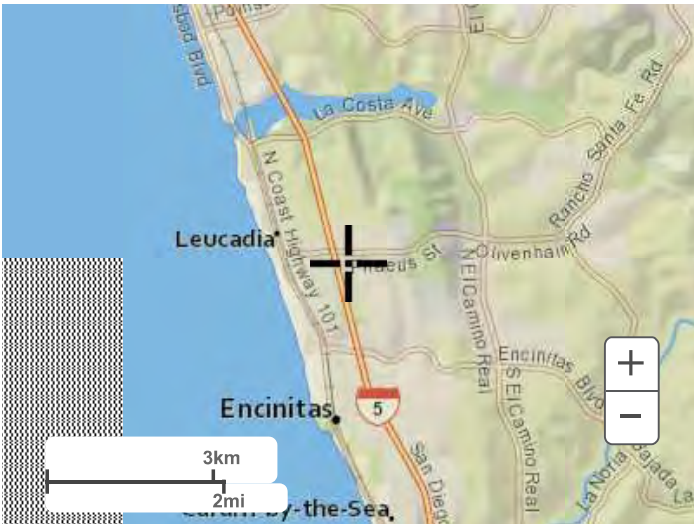
**PF graphical**



[Back to Top](#)

Maps & aerials

Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

## B.2 Loss Rate Calculations (Digital)

## **APPENDIX C**

### **Project Conditions Calculations**

1. Loss Rate Calculations (Land Use Based)
2. XPStorm (Digital Files)
  - a. 100-Year/24hr
  - b. 50-Year/24hr
  - c. 10-Year/24hr
  - d. 5-Year/24hr
3. Green Infrastructure Potential Sites (Digital File)
4. GIS Database Storm Drain Main Lines (Existing/Proposed) (Digital Files)